PB-220 194

BASELINE CHARACTERIZATION AND EMISSIONS CONTROL TECHNOLOGY ASSESSMENT OF HD GASOLINE ENGINES

Karl J. Springer

Southwest Research Institute

Prepared for:

Environmental Protection Agency

November 1972

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

APTD-1450

PB 220 194

BASELINE CHARACTERIZATION AND EMISSIONS CONTROL TECHNOLOGY ASSESSMENT OF HD GASOLINE ENGINES

by
Karl J. Springer

FINAL REPORT
Contract EHS 70-110

Prepared for
Environmental Protection Agency
Office of Air Programs
Mobile Source Pollution Control Program

November 1972

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO CORPUS CHRISTI HOUSTON

492

BIBLIOGRAPHIC DATA SHEET

1. Report No. APTD-1450

2\.

3. Recipient's Accession No. PB-220 194

4. Title and Subtitle

Baseline Characterization and Emissions Control Technology Assessment of HD Gasoline Engines

5. Report Date November 1972

6\.

7. Author(s) Karl J. Springer

8. Performing Organization Rept. No. AR-844

9. Performing Organization Name and Address

Southwest Research Institute
Post Office Drawer 28510
8500 Culebra Road
San Antonio, Texas 78284

10. Project/Task/Work Unit No.

11. Contract/Grant No. EHS 70-110

12. Sponsoring Organization Name and Address

ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Mobile Source Pollution Control Program
Ann Arbor, Michigan

13. Type of Report & Period Covered Final

14\.

15. Supplementary Notes

16. Abstracts

Six 1972 spark-ignited gasoline engines, used in trucks above 6,000 lbs. gross vehicle weight, were subjected to baseline exhaust emissions tests. Two groups of three engines, representing various cylinder configurations and displacements were tested by the current 1972 Federal test procedure, a nine-mode constant speed engine dynamometer test method. The concentrations were then converted to mass emissions for the nine-mode schedule using the 1974 Federal Test Procedure applicable to heavy-duty gasoline engines. Each engine was also tested by an experimental three-speed and multi-load schedule with expressions of emissions on a grams per bhp-hour basis. The emissions of interest were unburned hydrocarbons, oxides of nitrogen, carbon monoxide and aldehydes. One popularly used V-8 engine from each manufacturer's group was subjected to a limited series of laboratory tests to demonstrate control device effectiveness. The experimental multi-modal test procedure was employed to evaluate various control strategies such as basic spark timing, carburetion (air-fuel), air injection, exhaust gas recirculation and an oxidation catalyst singly and in combination. Substantial reductions in all emissions were effected on both engines with a combination of exhaust gas recirculation, air injection and an oxidation catalyst with some increase in fuel consumption and loss in maximum power.

17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Gasoline engines
Trucks
Exhaust emissions
Tests
Standards
Dynamometers
Sampling
Fuels
Hydrocarbons
Nitrogen oxides
Carbon monoxide
Aldehydes

Details of illustrations in this document may be better studied on microfiche

17b. Identifiers/Open-Ended Terms

Federal Test Procedure (1972)
Air pollution control
Federal Test Procedure (1974)

1a

17c. COSATI Field/Group 13B

18. Availability Statement Unlimited

19. Security Class (This Report) UNCLASSIFIED

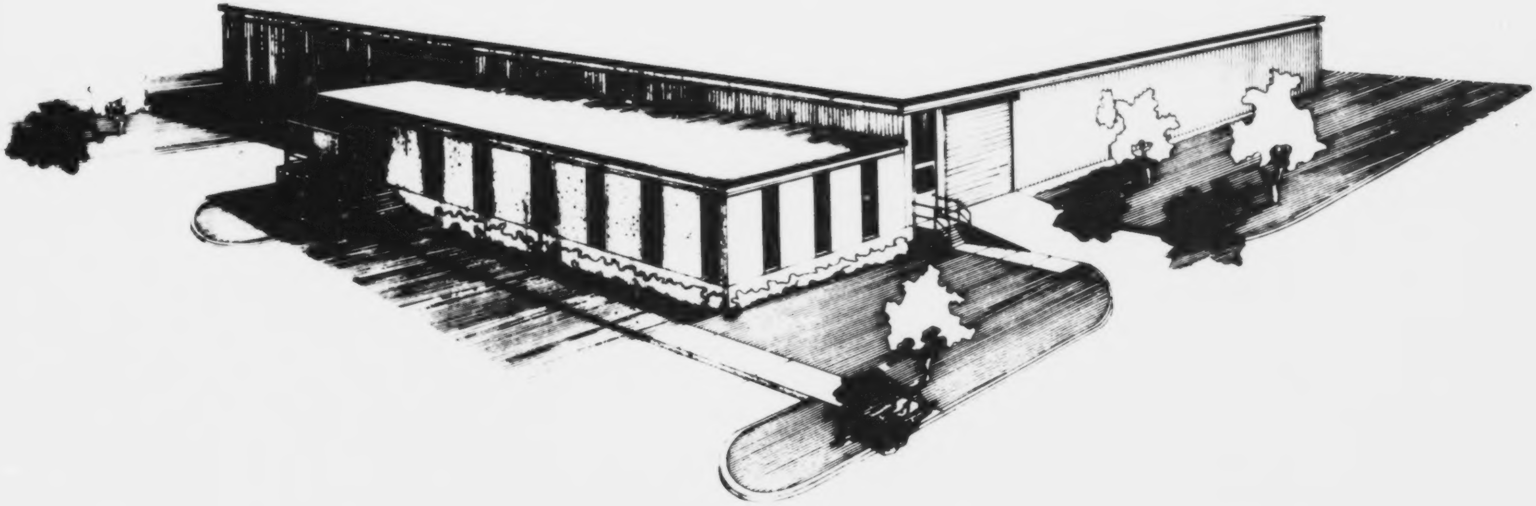
20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages ~~490~~ 492

22. Price $6.00 .95

FORM NTIS-35 (REV. 3-72)

USCOMM-DC 14952-P72



EMISSIONS RESEARCH LABORATORY

AR-844

SOUTHWEST RESEARCH INSTITUTE
Post Office Drawer 28510, 8500 Culebra Road
San Antonio, Texas 78284

BASELINE CHARACTERIZATION AND EMISSIONS CONTROL TECHNOLOGY ASSESSMENT OF HD GASOLINE ENGINES

by
Karl J. Springer

FINAL REPORT
Contract EHS 70-110

Prepared for
Environmental Protection Agency
Office of Air Programs
Mobile Source Pollution Control Program

November 1972

Approved:

jb John M. Clark

John M. Clark, Jr.
Technical Vice President
Department of Automotive Research

FOREWORD

This project was initiated by the Characterization and Control Development Branch, Division of Emission Control Technology, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, Michigan 48105. The engineering effort on which this report is based was accomplished by Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas, under contract number EHS 70-110. The author, Mr. Karl J. Springer, was the Project Leader of the research and development work. This project, authorized by Modification No. 3 to EHS 70-110, began on March 1, 1972, and was completed November 10, 1972.

The principal engineers associated with this project were Mr. Robert McFarland, who assisted with baseline data and Mr. Clifford D. Tyree, responsible for laboratory control technology evaluation.

The Project Officer cognizant of this project was Mr. John J. McFadden of the Characterization and Control Development Branch, Division of Emission Control Technology, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, Michigan 48105. This project was identified within Southwest Research Institute as No. 11-2877-01.

ABSTRACT

Six 1972 spark-ignited gasoline engines, used in trucks above 6,000 lbs. gross vehicle weight, were subjected to baseline exhaust emissions tests. Two groups of three engines, representing various cylinder configurations and displacements were tested by the current 1972 Federal test procedure, a nine-mode constant speed engine dynamometer test method. The concentrations were then converted to mass emissions for the nine-mode schedule using the 1974 Federal Test Procedure applicable to heavy-duty gasoline engines. Each engine was also tested by an experimental three-speed and multi-load schedule with expressions of emissions on a grams per bhp-hour basis. The emissions of interest were unburned hydrocarbons, oxides of nitrogen, carbon monoxide and aldehydes. One popularly used V-8 engine from each manufacturer's group was subjected to a limited series of laboratory tests to demonstrate control device effectiveness. This part of the study was restricted to the use of light-duty items or laboratory-type approaches because of the apparent lack of technology for gasoline engines in heavy-duty service. The experimental multimodal test procedure was employed to evaluate various control strategies such as basic spark timing, carburetion (air-fuel ratio), air injection, exhaust gas recirculation and an oxidation catalyst singly and in combination. Substantial reductions in all emissions were effected on both engines with a combination of exhaust gas recirculation, air injection and an oxidation catalyst with some increase in fuel consumption and loss in maximum power.

TABLE OF CONTENTS

Page

FOREWORD ii

ABSTRACT iii

LIST OF ILLUSTRATIONS v

LIST OF TABLES vii

I. INTRODUCTION 1

- A. Previous Projects 1
- B. Assistance by the Manufacturer 2
- C. Project Reviews 3

II. OBJECTIVE AND APPROACH 4

- A. Baseline Data 4
- B. Control Technology 4

III. EQUIPMENT, INSTRUMENTS, ENGINES, PREPARATION AND PROCEDURES 5

- A. Exhaust Sampling and Analysis 5
- B. Dynamometry and Related Facilities 8
- C. Engines 13
- D. Preparations 14
- E. Fuels 14
- F. Experimental Procedures 14
- G. Calculational Procedures 20

IV. RESULTS 30

- A. Baseline Results 30
- B. Control Technology Assessment 39

V. SUMMARY AND CONCLUSIONS 94

VI. RECOMMENDATIONS 98

LIST OF REFERENCES 99

APPENDIXES

LIST OF ILLUSTRATIONS

Figure		Page
1	Emissions Measuring Equipment Used With Nine Mode FTP and Experimental 23 Mode Procedure	9
2	Baseline Emissions Tests Equipment and Facilities	10
3	Dynamometer and Related Instruments and Equipment Baseline Tests	11
4	Engine Under Stationary Dynamometer Baseline Emissions Tests	12
5	Effect of Spark Timing on Emissions Engine 2-3, 23 Mode Test	46
6	Carburetor Rods, Jets, and Their Location (Engine 2-3)	48
7	Effect of Air-Fuel Ratio on Emissions Engine 2-3, 23 Mode Test	49
8	Exhaust Manifold Air Injection Equipment	51
9	Effect of Light Duty EGR and Air Injection on Emissions, Engine 2-3, 23 Mode Test	52
10	Light Duty EGR Equipment	53
11	Laboratory EGR System	54
12	Effect of Laboratory Cold EGR on Emissions Engine 2-3, 23 Mode Test	57
13	Oxidation Catalyst Test Set-up Engine 2-3	58
14	Effect of Oxidation Catalyst on Emissions Engine 2-3, 23 Mode Test	61
15	Effect of Oxidation Catalyst on 1972 Standard Engine Without Air and With Fuel Rich Mixture Engine 2-3, 23 Mode Test	62
16	Various Views of Oxidation Catalyst and Air Injection System Engine 1-3	72

LIST OF ILLUSTRATIONS (Cont'd)

Figure		Page
17	Laboratory Set-up for EGR Engine 1-3	74
18	Effect of Basic Spark Timing on Emissions Engine 1-3 23 Mode Test	76
19	Effect of Air-Fuel Ratio on Emissions Engine 1-3, 23 Mode Test	77
20	Effect of Laboratory Cold EGR on Emissions Engine 1-3, 23 Mode Test	79
21	Light Duty Exhaust Manifold Air Injection System	82
22	Effect of Oxidation Catalyst on Emissions with Slightly Modified Air Injection System Engine 1-3, 23 Mode Test	84
23	Effect of Combination of Hot EGR (Sch A), Oxidation Catalyst, Modified Air Injection on Emissions Engine 1-3, 23 Mode Test	88

LIST OF TABLES

Table		Page
1.	Fuel Inspection Results	15
2.	Current Federal Nine-Mode Constant Speed Procedure for Heavy Duty Gasoline Trucks	16
3.	Experimental 23 Mode Emissions Test Schedule (Heavy Duty Gasoline Engines)	18
4.	Explanation of Nine-Mode FTP Concentration Computer Printout Sheets	21
5.	Explanation of Nine-Mode FTP Brake Specific Computer Printout Sheets	24
6.	Explanation of Experimental 23 Mode Brake Specific Computer Printout Sheets	27
7.	Nine-Mode FTP Emission Results Concentrations per FTP	31
8.	Nine-Mode Emission Results per 1974 FTP Calculation Procedure	32
9.	Experimental 23-Mode Procedure Dry corrected Emission Results	34
10.	Comparison of Average Nine-Mode and 23 Mode Results, Six Engine Baseline	38
11.	Plan of Test, Engine 2-3	42
12.	Engine 2-3, 23-Mode Emission Reductions	65
13.	Engine 2-3 Nine-Mode 1972 FTP Emission Reductions (Concentration Basis)	66
14.	Engine 2-3 Nine-Mode 1974 FTP Emission Reductions (Mass Basis)	66
15.	Analysis of Nine Mode FTP HC Results, Engine 2-3	68
16.	Plan of Test, Engine 1-3	70
17.	Effect of Basic Spark Timing on Emissions 23-Mode Test, Engine 1-3	72

LIST OF TABLES (Cont'd).

Table — Page

18. Tailored EGR Schedules for Engine 1-3 — 80

19. Comparison of Emissions With and Without Light-Duty Air Injection System, Engine 1-3, 23-Mode Test — 81

20. Effect of Exidation Catalyst on Emissions, Engine 1-3, 23-Mode Test — 85

21. Effect of Various Control Combinations on Emissions, Engine 1-3, 23-Mode Test — 86

22. Effect of "Best Combination" on Emissions, Engine 1-3, 23-Mode Test — 90

23. Engine 1-3 Nine Mode FTP Emission Reductions (Concentration Basis) — 92

I. INTRODUCTION

According to statistical information(1)*, all trucks in 1970 comprised about 17 percent (18, 747, 781) of the total vehicles registered and burn approximately 28 percent of the gasoline consumed in the United States. From sales data(1), approximately 44 percent of the trucks and buses sold in 1970 were above 6, 000-lb gross vehicle weight (GVW). This estimate includes diesel vehicles which are a relatively small number.

The Environmental Protection Agency (EPA) has sponsored two programs, one at the Bureau of Mines under Inter Agency Agreement 0129 and the other at Southwest Research Institute to characterize baseline emissions from 15 heavy duty vehicle engine candidates and investigate the effectiveness of control technology. The effort described in this report by SwRI includes six (6) HDV engines supplied by two of the seven manufacturers who cooperated in the overall effort. The engine selection rationale considered engines with low emission levels, distribution of the application range greater than 6, 000-lb gross vehicle weight (GVW), high annual sales volume, diversified combustion chamber designs and availability of advanced emission control devices.

A. Previous Projects

Southwest Research Institute's Emissions Research Laboratory has conducted a considerable amount of research with HDVs beginning in June 1967. Past efforts included acquisition of baseline emissions data from 150 gasoline and LPG fueled spark-ignited engine-powered trucks and buses using three experimental road-like chassis dynamometer procedures. To acquire the emissions, a special truck version of the constant volume sampler (CVS) was used, which permitted expression of contaminants on a mass basis. The results of the survey are contained in the SwRI final report(2) which concluded that the three proposed experimental variable-speed cycles were not recommended for use in testing emissions from heavy-duty vehicles powered by spark-ignited engines. The findings of these earlier studies were summarized in AIChE and SAE papers(3, 4) which described the preparations and baseline data results, respectively.

The second major work in this program compared hydrocarbon (HC), carbon monoxide (CO), and nitric oxide (NO) emissions while driving in traffic to chassis dynamometer emissions by the Federal nine-mode constant speed cycle (FTP) for six trucks of various sizes and makes. Using a CVS, the current Federal cycle was submitted to a number of modifications to investigate what improvements might be made to make the Federal procedure agree more with road operation(5).

---

*Superscript numbers in parentheses refer to the List of References at the end of this report.

The third in this series of projects, sponsored by the Environmental Protection Agency, was completed in April, 1972. The first of the three-phase project was a broad emission characterization study of four 1969 trucks under a wide variety of engine speeds and power levels. Emission rates of hydrocarbons, carbon monoxide, and nitric oxide were expressed in mass units of grams per minute, per pound of fuel and per bhp-hr. In addition to the steady-state emission maps, a number of transient accelerations and decelerations were studied using a variety of simulated vehicle inertias. The second phase was a four-vehicle study of the effect of four different road routes on emission rates. The road routes were sufficiently different to be distinct, yet were considered representative of actual truck driving. The three phases of this project generated a large body of data that is summarized in the report(6) and included in some detail in a number of appendixes.

The precedent for the operation of gasoline engines on a 23-mode test procedure, with raw exhaust emission measurements expressed on a mass basis, was established in the project completed in April 1972(6). This present effort utilizes the equipment, instrumentation, and general test approach of the earlier project.

B. Assistance by the Manufacturer

Several meetings were held, beginning in January 1972, with representatives of two H. D. engine manufacturers involved in the SwRI studies. In attendance at these meetings were Mr. John J. McFadden and Dr. Jose Louis Bascunana representing the EPA and Mr. Karl Springer from SwRI. The objective of these meetings was to obtain the assistance, advice, and general support of the manufacturers in the project. As a result of these meetings, agreements were obtained as to engine displacement and selection of the three engines per manufacturer. Through the courtesy of the manufacturers, 1972 model engines were furnished for test. In the case of one manufacturer, the engines were new and in the case of the other, the engines were 125 hour certification engines. Also furnished by the manufacturers were the necessary exhaust piping, muffler, engine mounts, intake air cleaner, etc.

The major area of need for assistance from the manufacturers was in control technology hardware, data, and advice. Here, the manufacturers were unable to furnish more than selected items now used or previously used on light duty car engines. The general lack of help seemed to reflect the low priority given to emission control from gasoline engines in heavy duty service (above 6,000-lb GVW). The manufacturer's inability to furnish any specific or advanced concepts was taken to be a genuine and sincere expression of the current state-of-the-art as of that time. The manufacturers were quite helpful otherwise in assisting SwRI engineers in the course of the laboratory effort in furnishing technical assistance and special parts when requested. The efforts of the manufacturers must be commended, because without the help given, this project would have been much more difficult to perform. The unqualified thanks of SwRI go to both manufacturers.

C. Project Reviews

A number of meetings, discussions and status reviews were held during the course of this project with the Project Officer. They occurred on March 7th and 30th, June 1st, July 17th and August 16, 1972. These meetings, held on site in the Emissions Research Laboratory, were helpful in overall project management. Monthly progress reports and letter reports were issued to keep the Project Officer fully informed with complete data for analysis. Telephone reports were also made to augment the reports and correspondence.

II. OBJECTIVE AND APPROACH

The objective of this project was to obtain basic emissions data from six currently-produced gasoline-fueled engines and to investigate potentialities for emissions control with two of the more popular engines.

A. Baseline Data

The approach used with the six engines, three each from two manufacturers, was to measure their emission levels or rates using current and experimental test procedures. All engines were 1972 models and were operated on the stationary dynamometer test bed. The test procedure included both operations by the current nine-mode procedure described by the FTP(7) for expression as concentration and in brake specific emissions terms according to the method specified by the California ARB(8, 9). An experimental 23-mode engine test procedure with expression in grams per bhp-hour (brake specific) was also employed as specified by the Project Officer(10).

B. Control Technology

Two popularly used engines were subjected to a stepwise series of experiments to evaluate the effectiveness of various control approaches singly and in combination. For purpose of evaluation, the primary test procedure was the 23-mode EPA experimental method with nine-mode tests made of the best combination. Methods of control and parameters investigated included basic ignition timing, air-fuel ratio (main jet size variations), exhaust gas recirculation (EGR), oxidation catalysis, and exhaust manifold oxidation by air injection among others.

III. EQUIPMENT, INSTRUMENTS, ENGINES, PREPARATIONS AND PROCEDURES

This section contains a brief description of the instruments, equipment and facilities, engines, preparations and procedures used to conduct this project.

A. Exhaust Sampling and Analysis

Two basic types of exhaust sampling techniques were used during this program. The most familiar set of instruments used was the nondispersive infrared (NDIR) sampling train for raw exhaust gases specified in the Federal Register(7) for the nine-mode cycle (FTP). This system is described first. Another technique used was a variation of the continuous NDIR system in which raw exhaust was also analyzed by flame ionization detector (FID) and chemiluminescence (CL) instruments.

1. Nine-Mode Continuous Sampling, Analysis, and Instrumentation

The exhaust gas sampling and analysis system, for the FTP nine-mode cycle, meets the requirements and specifications established in the Federal regulations(7) for heavy-duty vehicle exhaust sampling. A component description of the system is detailed in the above referenced Federal regulations. Nominal full-scale concentration levels for the five NDIR analyzers are as follows:

(1) Low-Range HC - 1000 ppm hexane
(2) High-Range HC - 10,000 ppm hexane
(3) CO - 11 percent
(4) CO_2 - 16 percent
(5) NO - 4000 ppm

Although nitric oxide was not included in the current Federal regulations relating to gasoline HDVs at the time this project was done, this contaminant was important from a research standpoint.

The output of each analyzer is fed to strip-chart recorders. The concentrations from each trace can be obtained from the continuous traces by hand as specified in the nine-mode FTP. The average concentrations are then transferred to computer cards for further processing to obtain composite values for HC, CO, and NO. This method was used as a back-up to the real time computer system normally used. The computer system was designed and assembled by SwRI. This computer utilizes a Data General Super Nova, 8K central processor, and a Computer Products Series RTP 7410 multiplex. The computer program was also prepared by Institute personnel. This computer system was very helpful during this program to determine nine-mode FTP results immediately after completion of the tests. The reliability and repeatability of the on-line computer has been shown to be equal or better than manual chart reading and computer reduction of data.

The NDIR cart was subjected to a calibration according to EPA requirements. Both static and dynamic gas simulator tests were run initially on this cart by Mr. Matt Macocha of EPA during the period of September-November, 1971. Frequent calibrations of all NDIR, CL, and FID instruments were made to assure optimum accuracy. One of the EPA checks was to name an unknown contaminant to ± 1 percent, a difficult requirement since the basic detector is only specified to ± 1 percent by the manufacturer. Suffice to say that no tests were made until initial calibrations were satisfactorily completed.

2. Experimental 23-Mode Instrumentation

The use of direct stream, raw exhaust, emission sampling and analysis instruments has ample precedent in the case of NDIR type analyzers in which a fairly dry, clean sample is analyzed. To measure CO and CO_2, by NDIR, the usual continuous NDIR cart used for nine-mode FTP work was used. HC by NDIR was of secondary importance since it is known to grossly understate the HC concentrations in most modes of engine operation. The 23-mode method was to use an FID on the direct tailpipe raw exhaust that has not been cooled below the dew point of the water vapor contained therein. Condensation of water causes severe operational problems and it also is indicative of possible losses of some unburned hydrocarbons by condensation. For gasoline engine exhaust, the industry-accepted practice is to hold the sample, sample lines, and FID analyzers at about 160° F and, of course, no ice-water condensate trap was employed. Good operability at this temperature with an SwRI design HC analyzer had been found on another project dealing with off-road sources for EPA (Contract EHS 70-108).

In a previous project dealing with the 23-mode test(6), it was found that the Beckman Model 400 FID, widely used with diluted gasoline exhaust, was unsuited for raw gasoline engine exhaust. Rather than attempt to modify the instrument with uncertain results, it was decided to use an SwRI design FID and operate same at 160° F. The basic design and theory of operation was discussed in an SAE paper. Please refer to reference 11 for further details and description of the HC instrument.

To improve time response, the SwRI FID oven was located adjacent to the engine exhaust pipe. A fairly short stainless steel sample line, heated by a cylindrical heater, was controlled to maintain a 160° F gas temperature while oven temperature was held at 160° F. The sample probe was of standard design for auto exhaust and located adjacent to the probes used for the CO, CO2, and NO_x samples.

To monitor the HC sample bypass flow, a small rotameter was connected to the effluent from the FID. Since the water vapor was still in the exhaust and as it tends to condense in the rotameter at room temperature, a small ice trap was added before the rotameter but after the sample was split from the main stream and forced through the sample capillary. This is standard laboratory practice when a flowmeter is used to help monitor sample bypass flow.

A Thermal Electron Corp. (TECO) Model 10A chemiluminescent NO_x-NO analyzer, furnished by EPA, was used to measure NO_x. The TECO instrument analyzed a sample obtained via a separate line from the exhaust pipe. Since water vapor has a sizeable positive interference on the NDIR NO reading, a bone dry sample, commonly achieved by a chemical drying agent such as Aquasorb or Drierite has been standard practice. This has always been a controversial step in sample preparation and the recent trend has been, where possible, to use the chemiluminescent method which does not require it.

The TECO and other commercial chemiluminescent analyzers, however, were not designed to handle raw, undiluted, exhaust and suffer from operational difficulties if the majority of the water vapor is not removed. The current chemiluminescent analyzers operate at room temperature and do well with highly diluted exhaust such as from a constant volume sampler or with atmospheric samples. Raw exhaust contains the water vapor from combustion along with the intake air humidity and removal via an ice-water-type trap is necessary to prevent filling or coating the sample lines and capillary, leading to the reaction chamber, with water.

NO_2 is readily absorbed by water and the efficiency depends on residence and contact area. As the lesser of two evils, an ice-water-type trap with minimal residence time and water-to-sample contact time was used to prevent the sampling lines and other tubing, capillary, etc., within the instrument from becoming water logged. In practice, the same trap used for the NDIR was employed. No chemical drying agent such as Aquasorb or Drierite was used. On several occasions, the effect of the trap on NO_2 was checked by flowing a known concentration of NO_2 span gas through the system at various times during the run with the trap wet and the fiberglass particulate filter "dirty". From this, it was found that on an average about 10 to 15 percent of the NO_2 was lost, making all measurements of NO_2 subject to this error. One solution would be to heat the sample line, pump, etc., from point of sample to entrance of the sample into the reaction chamber.

An analysis of side-by-side NDIR and CL data from a previous project(6) revealed extremely close results and good correlation. The conclusion of such tests was that either system was satisfactory and the CL was preferred since it eliminates the difficult-to-resolve question of the effect of chemical drying agents on NO readings. The CL is not, however, without certain drawbacks as mentioned earlier.

Figure 1 shows several views of the instruments used for the nine-mode FTP and the 23-mode procedure with stationary-operated engines. The tall cabinet in the upper right and middle right view houses the NDIR NO and the CL NO_x instruments. Shown in the middle right view is the NDIR cart for HC, CO, and CO_2 analysis. The CO and CO_2 analyzers in this cart were used both ways, for nine and 23 mode testing. The lower right view shows the oven containing the heated portion of the HC instrument. The pump, filter, valves and detector, etc., are located in the oven with flow control module and electrometer located to the right of the oven.

Shown in the extreme right side of the lower right view is the glassware used to bubble exhaust through reagent for collection of aldehydes. Several runs on each engine, by the 23-mode procedure, included measurement of aliphatic aldehydes by the 3-methyl-2-benzylthiozolone hydrazine (MBTH) method(12, 13). This is a wet chemical method which is the popularly used technique for aldehyde determination. Its precision and adequacy for raw gasoline exhaust determination has not been thoroughly researched. The method was selected as the best available for a first approximation.

The lower left view in Figure 1 shows the heated sample line used for both HC and aldehyde sample transfer. It was felt important to locate instruments and glassware as close as practical to the exhaust system. All tests were made with samples obtained at a point representing average exhaust system length and the sample lines length kept to a minimum. Usually the sample lines were less than 36 inches. Other views of the instruments will be shown later in the report.

B. Dynamometry and Related Facilities

The two stationary all-electric engine dynamometers used in this project were completely equipped for constant speed motoring-absorbing and could perform the nine-mode FTP and the 23-mode experimental schedules satisfactorily.

1. Baseline Engines

The six baseline engines were operated in Cell 3 of the U. S. Army Fuels and Lubricants Research Laboratory at SwRI. The dynamometer and several typical engine installations are shown in Figures 2 to 4. This Eaton Dynamatic dynamometer is capable of 300 hp absorbing from 2,000 to 5,000 rpm and 50 hp motoring.

2. Control Technology Engines

Both control technology engines were then operated in the Emissions

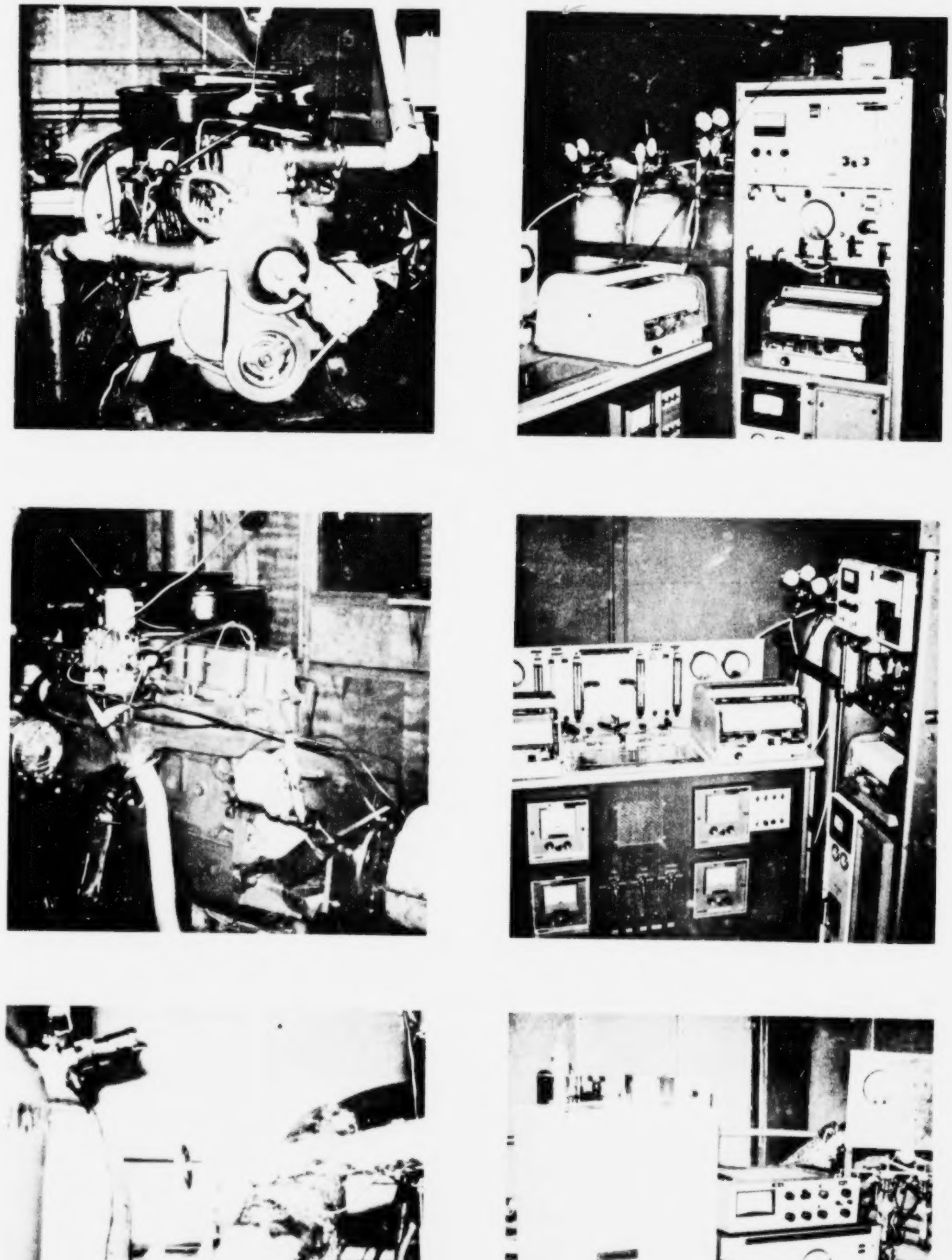


FIGURE 1. EMISSIONS MEASURING EQUIPMENT USED WITH NINE MODE FTP AND EXPERIMENTAL 23 MODE PROCEDURE

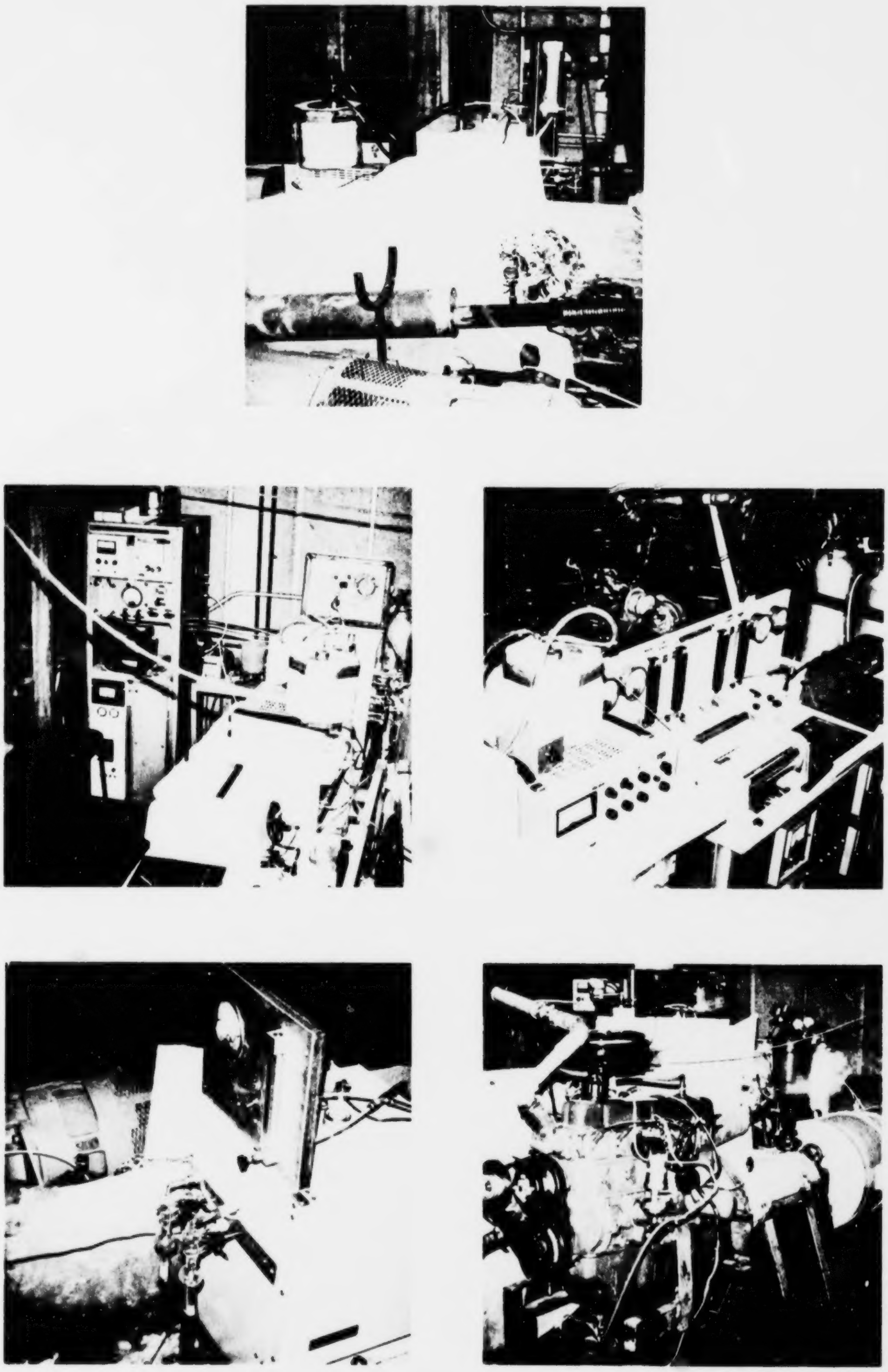


FIGURE 2. BASELINE EMISSIONS TESTS EQUIPMENT AND FACILITIES

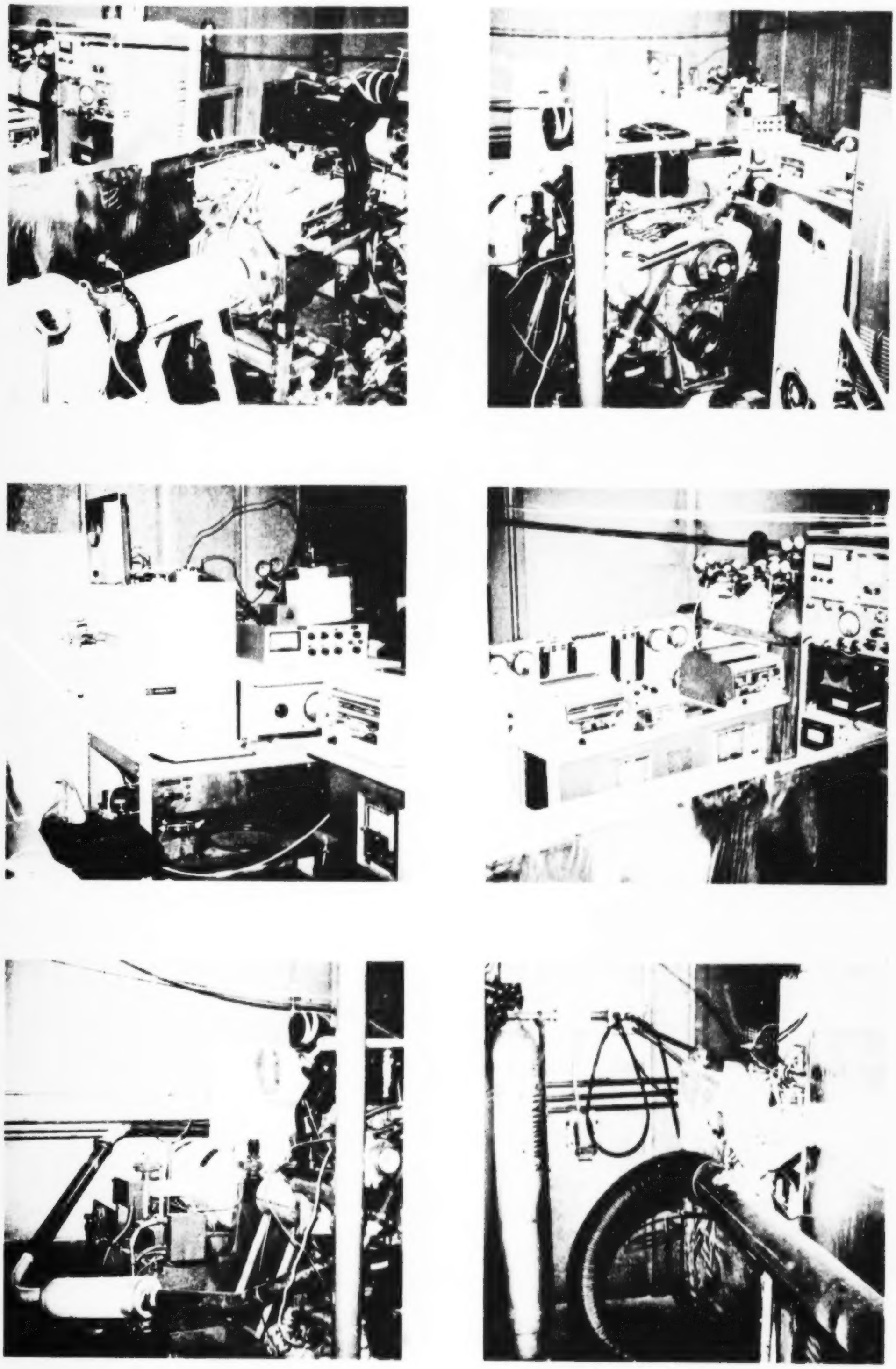


FIGURE 3. DYNAMOMETER AND RELATED INSTRUMENTS AND EQUIPMENT BASELINE TESTS

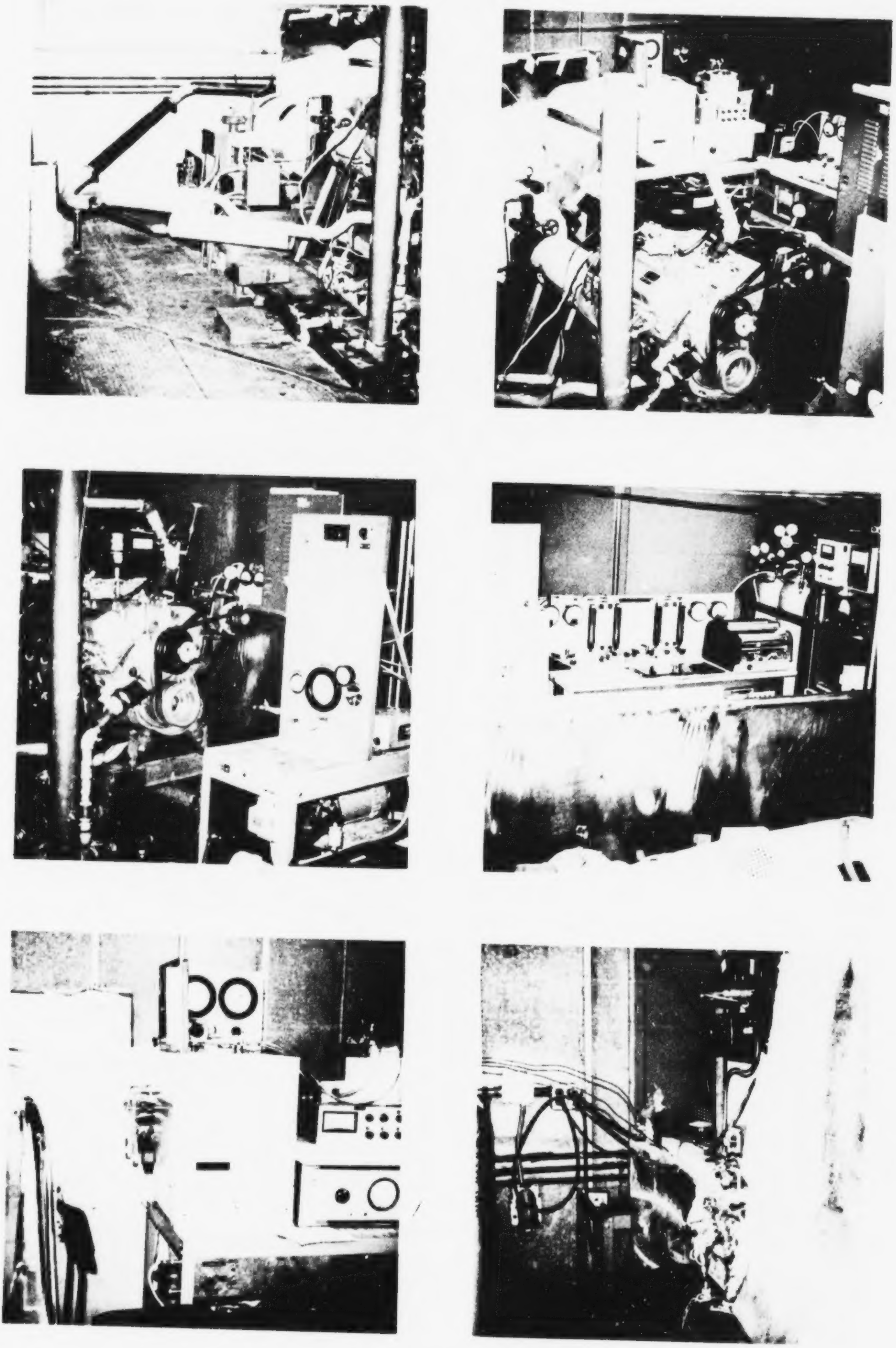


FIGURE 4. ENGINE UNDER STATIONARY DYNAMOMETER BASELINE EMISSIONS TESTS

Research Laboratory on a similar but larger Eaton Dynamatic dynamometer. This unit has capability to handle 500 hp absorbing (2,000 to 5,000 rpm) with 200 hp motoring. This dynamometer facility will be shown in the various views of engines and control systems later in this report.

3. Related Facilities

As important as the actual emissions measurements are the measurements of engine speed, power output and fuel consumption. The calibrations of the Standard Electric Time Co. speed systems were made by a calibrated strobotac (General Radio) and the hydraulic loading readout system by dead weight test. Fuel flow was measured by a Flo-Tron or weigh scale. Only weigh scale readings for the time (stop watch) to consume a known mass of fuel were used to compute mass emission rates with the baseline engines. A weigh scale calibrated Flo-Tron was used for the control technology engines.

A complete dynamometer installation was provided for measurement and control of engine operating parameters including inlet and outlet water temperature, inlet air temperature, exhaust temperature, oil pressure, exhaust backpressure and intake manifold vacuum. The latter pressure is critical to the nine-mode test and was periodically calibrated against a mercury column. Inlet air humidity was measured using a Bendix Model 566 wet-dry bulb temperature measuring instrument. The Bendix unit was periodically checked against a sling psychrometer. A conventional liquid-in-glass mercury barometer was used to measure barometric pressure and the observed reading suitably corrected.

C. Engines

In all, a total of six engines were obtained through the courtesy of the manufacturers. Two six cylinder in-line engines and four V-8 engines were used in the program. The engines were coded at the request of the manufacturers and with the concurrence of the Project Officer. The characteristics of the engines are listed below.

Test Engine Description

Engine Code	Adv. Flywheel Power(1) Bhp	@ rpm	Peak Torque Lb - Ft	rpm	GVW Application Min - Max, lbs
1-1	132	3500	239	2000	6,200 - 24,000
1-2	217	3200	398	1800	23,000 - 80,000(2)
1-3	152	3600	278	2200	16,000 - 50,000(2)
2-1	110	3800	185	1600	6,200 - 18,000
2-2	230	4000	360	2400	21,000 - 64,000(2)
2-3	175	4000	290	2400	6,200 - 26,000

(1)SAE J-245 (net)
(2)Gross Combined Weight

Engines 1-3 and 2-3 were used in the control technology assessment portion of the project. All engines were truck or truck version 1972 model year engines and had been built under the provisions of the 1972 certification regulations. Engines 1-1, 1-2, and 1-3 were the 125 hour certification engines. All engines were furnished to SwRI by the manufacturers along with necessary engine mounts, clutch-flywheel where desired and exhaust piping.

D. Preparations

The six engines subjected to baseline emissions measurements were provided by the manufacturers in ready-to-run condition. Since engines 2-1, 2-2, and 2-3 were new, a 25 hour break-in was given these engines before starting the emission test series. The variable speed and load run-in schedule was in accord with the manufacturer's recommendations. Once the engine was run-in or checked to make certain it was operating properly, the basic timing and idle speed were checked to make certain their adjustments were within the EPA factory sticker tune specifications. If not, adjustments were made. No adjustments were made to the idle air screws. These engines and carburetors were furnished with the usual plastic idle air screw adjustment limiters.

E. Fuels

The leaded premium fuel used during all baseline and control technology emissions tests met the requirements of the Federal Register(5). A typical fuel analysis of the fuel used and purchased locally is given in Table 1. Also shown on Table 1 is an inspection of the low lead Indolene clear motor fuel used in all control technology experiments involving the oxidation catalyst.

F. Experimental Procedures

All the engines were subjected to two basic laboratory stationary-operated engine procedures.

1. Nine-Mode FTP Schedule

The 1970 FTP (nine-mode 2,000 rpm constant speed procedure) is adequately described in the Federal Register(7). The test schedule is listed in Table 2. The procedure is 20 minutes in length and consists of the Table 2 schedule being run four times. The weighting factors, listed in the last column, are used to calculate the concentration results.

Please note that in reality, only six modes, of which only three are power-producing, are included in this 2,000 rpm constant speed procedure. The 16-inch condition is repeated four times for 35.6 percent of the weight. The other power-producing modes, Modes 3 and 7, the 10-inch and 3-inch

TABLE 1. FUEL INSPECTION RESULTS

	Leaded	Clear
Gravity, deg API (D287)	59.3	58.0
Distillation Range (D86)		
Initial Boiling Point, ° F	88	86
5% Point, ° F	116	
10% Point, ° F	127	128
20% Point, ° F	150	
30% Point, ° F	175	
40% Point, ° F	200	
50% Point, ° F	220	220
60% Point, ° F	235	
70% Point, ° F	254	
80% Point, ° F	276	
90% Point, ° F	305	315
95% Point, ° F	327	
End Point	340	409
% Recovery	98.0	98.0
% Residue	1.0	1.0
% Loss	1.0	1.0
Octane No., Research (D1656)	103.4	98.3
Total, % wt (D1266)	0.004	0.01
Reid Vapor Pressure, psi (D323)	9.1	9.2
Hydrocarbon Composition (D1319)		
Olefins, %	0.4	3.0
Aromatics, %	27.3	30.0
Saturates, %	72.3	67.0
Lead (Organic) g/gal (D526)	3.271	0.01
Phosphorus, Theory	0.0	0.0
Oxidation Stability (D525)	600+	
Existent Gum, mg (D381)	0.6	0.2

TABLE 2. CURRENT FEDERAL NINE-MODE CONSTANT SPEED PROCEDURE FOR HEAVY DUTY GASOLINE TRUCKS

Sequence Number	Manifold Vacuum	Time in Mode, sec	Cumulative Time, sec	Weighting Factors
1	Idle	70	70 (1:10)	0.036
2	16 in. Hg	23	93 (1:33)	0.089
3	10 in. Hg	44	137 (2:17)	0.257
4	16 in. Hg	23	160 (2:40)	0.089
5	19 in. Hg	17	177 (2:57)	0.047
6	16 in. Hg	23	200 (3:20)	0.089
7	3 in. Hg	34	234 (3:54)	0.283
8	16 in. Hg	23	257 (4:17)	0.089
9	Closed Throttle	43	300 (5:00)	0.021

Engine Speed 2000 ± 100 rpm.

An initial 5-min idle, two warmup cycles and two hot cycles constitute a complete dynamometer run.

modes, account for another 54 percent of the schedule. The three power modes, 16-inch, 3-inch, and 10-inch vacuum, represent a total of 89.6 percent of the cycle weight. The idle (3.6 percent weight), 19 inch (4.7 percent weight) and the closed throttle (2.1 percent weight) represent the remaining 10.4 percent of the cycle weight.

2. Experimental 23-Mode Schedule

The experimental 23-mode schedule is listed on Table 3 and is taken directly from the preliminary procedure, reference 10, provided by the Project Officer. A copy of this reference is included as Appendix Y. Note that modes 7, 9, and 10, at 1200 rpm engine speed, and modes 18, 20, and 21, at 2300 rpm engine speed, carry a zero weighting factor. Modes 7, 9, 10, 18, 20 and 21 were measured to obtain emission data that may be of use later. The 23-mode schedule and procedure is quite similar to the 1500-2500 rpm schedule studied earlier in the basic project and described in detail in the final report(6).

Although a 230 minute long, ten minutes per mode, test was described by the preliminary procedure, earlier work indicated that three minute long modes were quite adequate for an engine mapping-type procedure. As described in the final report(6) dealing with procedural development, the first minute is devoted to changing speed and load, the second minute for stabilization and only the time average of the third minute emission concentration used.

When measuring aliphatic aldehydes, a three-minute sampling period is needed and the three-minute schedule is extended to six minutes, with the third, fourth, and fifth minutes given over to wet collection of aldehydes. The sixth minute and first and second minutes of the next mode were used to wash down the fritted bubblers and exchange the bubbling reagent and holders.

Note that 12 minutes are allocated to mode 12. The additional nine minutes are provided to allow the HC analyzer and sampling system to purge after the very high HC concentration closed throttle (CT) raw exhaust samples have been analyzed. This procedure was found to be quite acceptable with regard to HC hang-up and is felt a necessary part of measuring the very high CT conditions.

One item that would have been helpful and is felt necessary for future 23-mode procedure work is a dual range CO or two different CO instruments. A 0-11 percent CO instrument is necessary under the WOT conditions, while at optimum combustion efficiency, such as about 50 ± 25 percent power, a much lower, say 0-1 percent CO instrument could be employed for improved accuracy. The situation is somewhat similar to the nine-mode NDIR HC instruments where two are needed, one for CT and selected other modes on

TABLE 3. EXPERIMENTAL 23 MODE EMISSIONS TEST SCHEDULE
(Heavy Duty Gasoline Engines)

Mode	Engine Speed, rpm	Power Out, %*	Mode Time	Cumulative Time	Weighting Factor
1	Idle	0	3	3	0.07
2	1200	2	3	6	0.06
3	1200	8	3	9	0.06
4	1200	18	3	12	0.05
5	1200	25	3	15	0.03
6	1200	50	3	18	0.06
7	1200	75	3	21	0.00
8	1200	82	3	24	0.04
9	1200	92	3	27	0.00
10	1200	100	3	30	0.00
11	Idle	0	3	33	0.07
12	1200	0 (CT)**	12	45	0.12
13	2300	100	3	48	0.025
14	2300	92	3	51	0.055
15	2300	82	3	54	0.035
16	2300	75	3	57	0.06
17	2300	50	3	60	0.06
18	2300	25	3	63	0.00
19	2300	18	3	66	0.065
20	2300	8	3	69	0.00
21	2300	2	3	72	0.00
22	Idle	0	3	75	0.08
23	2300	0 (CT)**	3	78	0.06

*Observed at the flywheel, percent of maximum at a given engine rpm.
**Power out is zero. Engine requires motoring in this mode.

occasion,while all others are read on a 0-1000 ppm scale. A multirange unit like a 315 B Beckman is only good to a five times factor, making say 0-1 and 0-11 percent impossible by merely the range gain amplification. Either stacked cells or two separate instruments is the answer in this regard.

3. Engine Test Method

The specific test procedure followed for a baseline engine, assuming the engine has been proof tested with power, torque, fuel rate, etc., as expected and any run-in or break-in completed, was essentially as follows:

First, replicate nine-mode tests were made, at least three times with one hour shut down between tests. The full 20 minute schedule was followed. Then, the engine power readings and fuel consumption rates were determined in replicate. These measurements are necessary to convert the nine-mode concentrations to grams per bhp-hour using the carbon balance method specified in the California ARB Procedure(8, 9). It is not possible to measure the fuel accurately during the fairly busy nine-mode schedule (see Table 2 for mode times) and therefore, such measurements are normally obtained at the conclusion of the test.

Next, NO NDIR and both NDIR HC analyzers were switched out and the NO-NO_2 CL and heated FID were switched into the sampling and analysis system. The 23-mode procedure calls for operation at specific percentages of maximum power at 2300 and 1200 rpm. As soon as the engine was thoroughly warmed up, the maximum observed flywheel power output of the engine was determined by operating alternatively at WOT at 1200 rpm and 2300 rpm.

In actual operation, the 23-minute procedure was preceded by a 10-minute operation at 2000 rpm, half-load to warm up the engine. During the last few minutes, the analyzers were zeroed and spanned, ice-water traps drained and filters renewed. The engine then began the initial idle mode of the 23-mode test. In practice, the test was not difficult since the first minute of each 3-minute mode was allocated to adjust engine speed and load, the second minute was devoted to engine-emission stabilization, and the final minute the emissions were continuously recorded and integrated to determine modal concentrations.

More than 3 minutes may be used at the center idle, mode 11, to do maintenance on the sampling and analysis equipment. Normally, as soon as the first closed throttle was complete, Mode 12, the HC system was purged with zero N_2 while other instruments were spanned and zeroed. Then the HC instrument was spanned and zeroed, water traps were drained, filters replaced, and all instruments rechecked for zero and span before starting Mode 13. At any mode during the test, the instruments could be zeroed and spanned, if desired, as long as it was done during the first 1-1/2 minutes of the mode. In practice, the ice-water traps were drained after the 5th and 17th modes of the test.

G. Calculational Procedures

The emission results were calculated in three ways:

1. Nine-Mode FTP - Concentrations

The calculations of the final result of ppm n hexane HC, and percent CO followed the nine-mode procedure as specified in detail by the Federal Register(7). In effect, the raw NDIR readings in ppm are adjusted by a dilution factor

$$\text{Dilution Factor} = \frac{14.5}{CO_2\,\% + 0.5\,(CO\% + 10.8\ HC\ \%\ n\ \text{hexane})}$$

and then multiplied by the appropriate weighting factor. These were listed earlier in Table 2.

The on-line process computer was normally used with manual strip chart-computer reduction as an alternative. The computer print-out is so arranged to list as-measured raw concentrations, the adjusted, weighted and sum composite values. Since this is a standard method, the reader is referred to Reference 7 for complete details. Table 4 is an explanation of the nine-mode FTP concentration computer print-outs.

Although not covered by current Federal regulations, NO during the nine-mode FTP was measured by NDIR. The results were treated the same as the CO and HC, i.e., adjusted for dilution and application of the weighting factor. Since water vapor or inlet air humidity has a measurable effect on NO formation in combustion engines, this reading is normally presented both on an observed and corrected basis. The conventional correction basis is 75 grains of water per pound of dry air absolute humidity and is determined by multiplying the observed NO by the correction factor

$$\text{Correction Factor } (K) = 0.6272 + 0.00629H - 0.0000176H^2$$

where H = absolute humidity of the air

This expression is identical to that in the current heavy-duty gasoline truck surveillance project (Contract EHS 70-113). The factor came from results of an AMA project described in Reference 14.

2. Nine-Mode ARB - Brake Specific

This method, described in References 8 and 9 utilizes the carbon

TABLE 4. EXPLANATION OF NINE-MODE FTP CONCENTRATION COMPUTER PRINTOUT SHEETS

1. Column Explanation

Column	Column Title	Explanation
1	FEDERAL MODE	Mode number and inlet vacuum (inches of mercury)
2	AS MEASURED HC	Measured hydrocarbon emissions, ppm or n-hexane
3	AS MEASURED CO	Measured carbon monoxide emissions in percent
4	AS MEASURED CO_2	Measured carbon dioxide emissions in percent
5	AS MEASURED NO	Measured nitrogen oxide emissions in ppm
6	DILUTION FACTOR	Dilution factor for each mode calculated by equation shown at bottom of printout
7	ADJUSTED HC	Measured HC times the dilution factor (PPM-hexane)
8	ADJUSTED CO	Measured CO times the dilution factor (percent)
9	ADJUSTED NO	Measured NO times the dilution factor (PPM)
10	WEIGHTING FACTOR	Weighting factor assigned to each mode
11	WEIGHTED HC	Adjusted HC times weighting factor
12	WEIGHTED CO	Adjusted CO times weighting factor
13	WEIGHTED NO	Adjusted NO times weighting factor

2. Line Explanation

1st Line

(X) - (XX) - 72	Date in month, day and year
ENGINE (X) - (X)	SwRI engine identification number
RUN (X)	Run Number. Runs numbered sequentially. The first run for a given day in run 1.

TABLE 4 (CON'T). EXPLANATION OF NINE-MODE FTP CONCENTRATION COMPUTER PRINTOUT SHEETS

K = (X.XX)	Humidity correction factor for cycle composite NO. $K = .6272 + .00629\,H - .0000176H^2$. Where H = absolute humidity in grams/lb DA
HUM = (XXX) GR/LB	Absolute humidity in grams/lb DA during run
Line Starting SUM - CYCLE COMPOSITE	Sumation of each weighted emission type
AVERAGE SUM - (COMPOSITE VALUES FOR CYCLES 1 AND 2)	$\frac{\text{SUM (cycle 1)} + \text{SUM (cycle 2)}}{2}$
AVERAGE SUM - (COMPOSITE VALUES FOR CYCLES 3 AND 4)	$\frac{\text{SUM (cycle 3)} + \text{SUM (cycle 4)}}{2}$
FOUR CYCLE COMPOSITE	Composite value for each emission using formula shown
CORRECTED NO	Composite NO times K

balance method to establish the exhaust mass rate. It is necessary to know precisely the fuel consumption rate as well as CO, CO_2, and HC, the principal carbon-bearing products of combustion. Since it is desired to express the emission rate on a brake specific basis in terms of grams of contaminant per brake horsepower-hour, it is also necessary to accurately measure or know the power output at the flywheel. With the modal concentrations (raw) from the nine-mode test and the fuel rate and power output modally, the determination of mass rates by the 1974 FTP is a straightforward calculation. A computer was used and the print-out sheets are explained on Table 5.

All data presented in this report use the latest density, correction factor for NO_2 and weighting factors per Reference 9. The correction factor

$$K = 0.634 + 0.00654H - 0.0000222H^2$$

where H is the grains of water per pound of dry air was used to correct observed NO to NO at 75 grains humidity, standard.

Reference 9 also changed the weighting factors from those historically used with the California and Federal nine-mode test for weighting the emission concentrations. Because of the importance of weighting factors on the final result, the current ARB weighting factors are listed along with the FTP weighting factors.

ARB Weighting Factors for Nine-Mode Mass Emissions

Mode	Vac, in Hg	Previous*	Current
1	Idle	0.036	0.232
2	16	0.089	0.077
3	10	0.257	0.147
4	16	0.089	0.077
5	19	0.047	0.057
6	16	0.089	0.077
7	3	0.283	0.113
8	16	0.089	0.077
9	C. T.	0.021	0.143

*Currently used in the FTP(7) and contained in earlier ARB proposals(8).

In essence, the latest California ARB factors give substantially more weight to closed throttle and idle modes and less weight to the 10-inch and 3-inch modes. Recall that neither the idle or closed throttle are power producing, with the net effect that cycle power is less when weighted making the denominator smaller and the quotient larger.

TABLE 5. EXPLANATION OF NINE-MODE FTP BRAKE SPECIFIC COMPUTER PRINTOUT SHEETS

1. Column Explanation

Column	Column Title	Explanation
1	MASS MODE	Mode number and inlet vacuum (inches of mercury)
2	AS MEASURED HC	Measured hydrocarbon emissions, ppm or n-hexane
3	AS MEASURED CO	Measured carbon monoxide emissions in percent
4	AS MEASURED CO_2	Measured carbon dioxide emissions in percent
5	AS MEASURED NO	Measured nitrogen oxide emissions in ppm
6	TOTAL CARBON	The percentage of exhaust gas that is carbon containing gases
7	FUEL CONS.	Engine fuel consumption in Grams/Hr.
8	ADJUSTED (MASS) HC	Hydrocarbon emissions in Grams/Hr. calculated from measured HC
9	ADJUSTED (MASS) CO	Carbon monoxide emissions in Grams/Hr. calculated from measured CO
10	ADJUSTED (MASS) NO_2	Nitrogen dioxide emissions in Grams/Hr. calculated from measured NO
11	WT. FACT.	Weighting factor for each mode
12	WEIGHTED (MASS) HC	Hydrocarbon emissions in Grams/Hr. times the weighting factor
13	WEIGHTED (MASS) CO	Carbon monoxide emissions in Grams/Hr. times the weighting factor
14	WEIGHTED (MASS) NO_2	Oxides of nitrogen emissions as NO_2 Grams/Hr. times the weighting factor
15	HP	Engine horsepower from dynamometer

TABLE 5 (CONT.) EXPLANATION OF NINE-MODE FTP BRAKE SPECIFIC COMPUTER PRINTOUT SHEETS

2. Line Explanation	Explanation
1st Line	
(X) - (XX)-72	Date in month, day and year
ENGINE (X)-(X)	SwRI engine identification number
RUN (X)	Run number. Runs numbered sequentially. The first run for a given day in run 1.
K = (X.XX)	Humidity correction factor for cycle composite NO_2. $K = .634 + .00654 H - .0000222H^2$. Where H = absolute humidity in grams/lb DA
HUM = (XXX) GR/LB	Absolute humidity in grams/lb DA during run
Line Starting	
SUM - CYCLE COMPOSITE	Grams/BHP-HR for cycle, sumation of each weighted emission divided by the sumation of horsepower times weighting factor, i.e. $\frac{\sum \text{Emission x W.F.}}{\sum \text{H.P. x W.F.}}$
AVERAGE SUM -(COMPOSITE VALUES FOR CYCLES 1 AND 2)	$\frac{\text{SUM (cycle 1) + SUM (cycle 2)}}{2}$ Grams/BHP-HR
AVERAGE SUM -(COMPOSITE VALUES FOR CYCLES 3 AND 4)	$\frac{\text{SUM (cycle 3) + SUM (cycle 4)}}{2}$
FOUR CYCLE COMPOSITE	Composite of all four cycles in Grams/BHP-HR using formula shown
CORRECTED NO_2	Four cycle composite NO_2 in grams/BHP-HR times the humidity correction factor, K.

3. Experimental 23-Mode Calculations

This experimental procedure and its calculational method was provided by the Project Officer for use in this project(10). The calculational methods followed fairly closely those established for the 23-mode procedure used in Reference 6. The engine speeds were slightly lower, the power levels changed and the weighting factors were different but the method of calculation, using the carbon balance technique, remained the same. As a consequence of correspondence between Mr. Mel Ingalls of Southwest Research Institute and Mr. John Bozek of Environmental Protection Agency, the calculation procedure for the 23-mode data was clarified. As confirmed by letter from Mr. Ingalls to Mr. Bozek on April 17, 1972, all data was expressed on a dry basis.

Table 6 is an explanation of the computer print-out sheets and illustrates how the final grams of HC, CO, or NO_2 were determined from the raw concentrations, fuel rate and power output data. Note that the print-out includes aldehydes so that this emission could be expressed on a brake specific basis of grams of formaldehyde per bhp-hour. The colorimetric determination of aliphatic aldehydes is in terms of the simplest aldehyde, formaldehyde.

Beginning with engine 2-3, the last baseline and the first control technology engine, the computer print-out included air-fuel ratio (AFR) by the Spindt calculation method. This is listed on the computer print-out where fuel in grams per hour once was. This addition to the print-out information necessitated the addition of O_2 measurement by a Beckman polarographic method. The Spindt Calculation is included in the explanation of the 23-mode computer print-out, Table 6. For additional description of this method, please refer to Reference 15. The air-fuel ratio computed by this method agrees with the air-fuel ratio calculated by one other method and was felt reliable enough for purposes of this project. All of the calculational methods used in this project were discussed in detail with the Project Officer and his approval obtained for their use. Changes in print-out format, factors, corrections, etc., were effected when requested to conform with the latest procedures and methods available to EPA and SwRI.

TABLE 6. EXPLANATION OF EXPERIMENTAL 23 MODE BRAKE SPECIFIC COMPUTER PRINTOUT SHEETS

Column	Column Label	Explanation
Upper table		
1	MODE	Mode number (1-23)
2	SPEED	Engine speed in rpm
	DYNAMOMETER LOAD	Measured dynamometer load in ft-lbs
4	HP	Horsepower calculated from dynamometer load and speed using equation: $HP = \frac{(ft\text{-}lbs) \times rpm}{5252}$
5	MAN. VAC.	Measured manifold vacuum in inches of Mercury
6	FUEL RATE LB/HR	Measured lb/hr of fuel used
7 *	FUEL RATE GM/HR	Fuel rate in grams per hour calculated from equation: $GM/HR = 453.6 \times lbs/hr$
8	DRY CONCENTRATION ALDE	Measured aldehyde emission concentration as formaldehyde (ppm) corrected to a dry (water from combustion removed) basis by the equation: $ALDE = ALDE\ (\text{as measured wet}) \times K_1$ where $K_1 = \frac{(100 + .925\ (CO\% - CO_2\%)}{100}$
9	DRY CONCENTRATION HC	Measured hydrocarbon emission concentration (ppmC) corrected to a dry basis as above.
10	DRY CONCENTRATION CO	Measured carbon monoxide emission concentration, % by volume. Measured dry with water of combustion removed.
11	DRY CONCENTRATION CO_2	Measured carbon dioxide emission concentration, % by volume. Measured dry.
12	DRY CONCENTRATION NO_x	Measured oxides of nitrogen emission concentration as NO (ppm). Measured dry.

TABLE 6. (Cont'd) EXPLANATION OF EXPERIMENTAL 23 MODE BRAKE SPECIFIC COMPUTER PRINTOUT SHEETS

Column	Column Label	Explanation
Lower Table		
1	MODE	Mode number (1-23)
2	CALCULATED GRAM/ HR ALDE	Calculated aldehyde emission concentration as formaldehyde in grams/hr $\text{ALDE(gm/hr)} = 2.16 \times \frac{\text{ALDE}}{10000} \times \frac{\text{fuel flow(grams/hr)}}{\text{total carbon}}$ where Total Carbon= $\text{CO}_2\% + \text{CO}\% + \frac{\text{HC(ppm)}}{10000}$
3	CALCULATED GRAM/HR HC	Calculated hydrocarbon emission concentration in grams/hr $\text{HC(gm/hr)} = \frac{\text{HC}}{10000} \times \frac{\text{fuel flow(grams/hr)}}{\text{total carbon}}$
4	CALCULATED GRAM/ HR CO	Calculated carbon monoxide emission concentration in grams/hr $\text{CO} = 2.02 \times \text{CO} \times \frac{\text{fuel flow(grams/hr)}}{\text{total carbon}}$
5	CALCULATED GRAM/HR NO_2	Calculated oxides of nitrogen emission concentration as NO_2 in grams/hr $NO_2 = 3.32 \times \frac{\text{NO}}{1000} \times \frac{\text{fuel flow(grams/hr)}}{\text{total carbon}}$
6	WT. FAC.	Weighing factor for each mode
7	WT. HP	Weighted horsepower. HP (Column 4) times weighting factor (Column 16)
8	BRAKE SPECIFIC ALDE	Aldehyde, gm/hr, (Column 2) divided by HP (Column 4, upper table) for the individual mode. "R" in table indicates indeterminate value.
9	BRAKE SPECIFIC HC	HC, gm/hr, (Column 3) divided by HP (Column 4, upper table) for the individual mode
10	BRAKE SPECIFIC CO	CO, gm/hr, (Column 4) divided by HP (Column 4, upper table) for the individual mode.
11	BRAKE SPECIFIC NO_2	NO_2, gm/hr, (Column 5) divided by HP (Column 4, upper table) for the individual mode.

TABLE 6. (Cont'd) EXPLANATION OF EXPERIMENTAL 23 MODE BRAKE SPECIFIC COMPUTER PRINTOUT SHEETS

CYCLE COMPOSITE	Explanation
HC, CO, NO_2, ALDE	Summation of emission for each mode times weighting factor divided by summation of weighted horsepower for each mode. $\dfrac{\sum_{i=1}^{23} \text{Emission}_{(i)} \times \text{W. F.}_{(i)}}{\sum_{i=1}^{23} \text{HP}_{(i)} \times \text{W. F.}_{(i)}}$
BSFC	Summation of fuel flow (lbs/hr) times weighting factor for each mode divided by summation of weighed horsepower for each mode. $\dfrac{\sum_{i=1}^{23} \text{Fuel flow (lb/hr)}_{(i)} \times \text{W F}_{(i)}}{\sum_{i=1}^{23} \text{HP}_{(i)} \times \text{W F}_{(i)}}$

* For engine 2-3, this column was replaced with air-fuel ratio by the Spindt calculation formula and all control technology data includes AFR by this method.

$$FB(I) = \frac{(CO(I) + CO_2(I))}{TC(I)}$$

$$AFR = FB\left\{9.8831\left[\frac{\left(1 + \frac{CO(I)}{2(CO_2(I))} + \frac{O_2(I)}{CO_2(I)}\right)}{1 + \frac{CO(I)}{CO_2(I)}}\right] + \left[\frac{16.8}{3.5 + \frac{CO(I)}{CO_2(I)}}\right]\right\}$$

IV. RESULTS

The results of this project are presented in two segments; the first, covering the six baseline engines and the second, the control technology experiments with two engines.

A. Baseline Results

The baseline results for all six engines are described by the type of test conducted namely, FTP concentration, FTP mass and 23-mode mass.

1. Nine-Mode FTP Concentration

Table 7 is a complete listing of the nine-mode results in terms of ppm n hexane, percent CO and ppm NO observed and corrected. The replicate run data for each engine is listed by engine in the order tests were run. An average of the three run results is shown and may be directly compared to the current 1972 limits of 275 ppm n hexane and 1.5 percent CO. For a given engine, the test repeatability was judged normal and satisfactory.

Different engines had different emissions behavior with the range in HC from 88 to 234 ppm n hexane, the range in CO from 0.31 to 1.42 percent, and the range in corrected NO from 1322 to 2174 ppm. Engine 1-1, 1-2, and 1-3 results compare favorably with certification results. Little more can be said about these results, except to compare them to proposed standards of 160 ppm n hexane, 0.8 percent CO and 2,000 ppm NO (corrected) published in the October 5, 1971 Federal Register.(16)

2. Nine-Mode FTP Mass Emissions

Table 8 summarizes the replicate runs made on the six baseline engines in the order tested. It is difficult to make many comments on the results relative to the 1973 California and 1974 Federal limits of 40 grams of CO per bhp-hour and 16 grams of HC + NO_2 (corrected). The range of CO was 14.8 to 69.2 grams per bhp-hour and the range of HC + NO_2 was 14.6 to 21.3 grams per bhp-hour. Most engines appear to have little problem in meeting the CO and are nearly there on HC + NO_2. Generally, the manufacturers try to have a fairly good margin between the engine emissions rate and the limits.

What action will be taken by the manufacturers to meet 1975 California limits of 25 grams CO and 5 grams HC + NO_2 per bhp-hour is unknown at this time. It would seem that substantial improvements will be necessary to meet the apparently stringent 5 gram standard. Just as the nine-mode FTP concentration run-to-run repeatability was good, so was the repeatability good for the mass calculations. The fuel rate and power levels are fairly constant so that only raw emission concentrations have an effect on run-to-run repeatability. The FTP mass rates "track" the concentrations as would be expected.

TABLE 7. NINE-MODE FTP EMISSION RESULTS
CONCENTRATIONS PER FTP

Engine	Date	Run	HC ppm Hex	CO %	Observed NO, ppm	Corrected NO, ppm	Humidity gr/lb d. a.
2-1	3/6/72	1	90	0.35	2188	2041	58
2-1	3/6/72	2	95	0.29	2052	1998	68
2-1	3/6/72	3	80	0.29	2071	2032	70
		Average	88	0.31	2104	2024	
1-1	3/21/72	1	112	0.39	2020	1902	60
1-1	3/21/72	2	99	0.40	2132	1980	57
1-1	3/21/72	3	106	0.52	2691	2641	70
		Average	106	0.44	2281	2174	
1-2	4/6/72	2	228	0.71	1894	2052	101
1-2	4/6/72	3	233	0.71	1934	2153	113
1-2	4/6/72	4	240	0.70	1988	2163	103
		Average	234	0.71	1939	2123	
2-2	4/14/72	2	162	1.42	1173	1313	116
2-2	4/14/72	3	164	1.43	1227	1364	112
2-2	4/14/72	4	170	1.42	1177	1290	106
		Average	165	1.42	1192	1322	
1-3	4/24/72	1	117	0.36	1825	1517	36
1-3	4/25/72	2	124	0.30	1749	1578	51
1-3	4/25/72	3	114	0.27	1836	1488	32
		Average	118	0.31	1803	1528	
2-3	5/12/72	1	111	0.66	1411	1593	120
2-3	5/12/72	2	110	0.65	1398	1589	124
2-3	5/12/72	3	126	0.67	1432	1622	122
		Average	116	0.66	1414	1601	
	1972 Limit (Fed)		275	1.5	No Standard		

TABLE 8. NINE-MODE EMISSION RESULTS PER 1974 FTP CALCULATION PROCEDURE

			Grams/bhp-hr					
Engine	Date	Run	HC	CO	Obs. NO_2	Corr. NO_2	Corr. $HC+NO_2$	Humidity gr/lb d.a.
2-1	3/6/72	1	3.28	17.3	15.6	14.6	17.9	58
2-1	3/6/72	2	3.41	13.5	14.7	14.3	17.7	68
2-1	3/6/72	3	2.76	13.5	14.8	14.5	17.3	70
		Average	3.15	14.8	15.0	14.5	17.6	
1-1	3/21/72	1	3.24	17.0	13.4	12.6	15.9	60
1-1	3/21/72	2	2.88	16.6	14.1	13.2	16.0	57
1-1	2/21/72	3	3.10	21.2	17.8	17.5	20.6	70
		Average	3.07	18.3	15.1	14.4	17.5	
1-2	4/6/72	2	7.16	32.8	12.7	13.6	20.7	101
1-2	4/6/72	3	7.36	32.7	13.1	14.1	21.5	113
1-2	4/6/72	4	7.46	32.2	13.3	14.3	21.8	103
		Average	7.33	32.6	13.0	14.0	21.3	
2-2	4/14/72	2	5.62	69.3	9.1	10.0	15.6	116
2-2	4/14/72	3	5.61	69.4	9.6	10.4	16.0	112
2-2	4/14/72	4	5.88	68.9	9.2	9.9	15.8	106
		Average	5.70	69.2	9.3	10.1	15.8	
1-3	4/24/72	1	4.42	18.3	14.4	12.1	16.5	36
1-3	4/25/72	2	4.71	15.3	13.8	12.6	17.3	51
1-3	4/25/72	3	4.45	13.9	14.5	11.9	16.4	32
		Average	4.53	15.8	14.3	12.2	16.7	
2-3	5/12/72	1	3.22	31.2	10.2	11.2	14.4	120
2-3	5/12/72	2	3.23	31.1	10.1	11.1	14.3	124
2-3	5/12/72	3	3.63	31.9	10.3	11.3	15.0	122
		Average	3.36	31.4	10.2	11.2	14.6	
1973 Limit (Cal.)				40			16	
1975 Limit (Cal.)				25			5	

The analysis made using the FTP procedure indicated that it is very sensitive to fuel rate, especially HC results. Low fuel rates occur at idle, CT, and 19 inch vacuum modes where HC are generally high. A small error in fuel rate can make a severe error in the HC results. Since only three modes actually produce measurable power, the 16, 10, and 3 inch modes, the cycle composite is quite dependent on precise power measurements.

3. Experimental 23-Mode Mass Emissions

Table 9 contains summary data for the many replicate runs made to determine baseline emissions from the six engines by the experimental 23-mode procedure. The overall run-to-run repeatability seemed satisfactory for HC, CO, and NO_2. A comparison against a target or desired level is not possible since, at this writing, none exist.

Measurement of aldehydes was attempted and though the overall run-to-run results look good, the modal concentration repeatability was not very good. The problem of trying to measure aldehydes by MBTH was of continual concern during this project. Calibration of the entire system using bags of air + trace quantities of formaldehyde have given routine precision of ± 10 to 15 percent normally. Some if not most of the lack of repeatability must be due to the engine and the remainder to the sampling, gas washing and colorimetric analysis. It is uncertain whether the MBTH approach is satisfactory, but it is the best known method for measurement of repetitive samples.

The following is an engine-by-engine summary of the general operation and experience regarding the 23-mode test.

(a) Engine 2-1: Testing of this engine began on March 6, 1972 with the running of the nine-mode Federal test. Prior to making the tests, a 25 hour break-in at various speeds and loads (according to a schedule used by the manufacturer) was completed. The basic timing and engine idle speed was then adjusted to that specified by the manufacturer, namely 4° BTDC and 700 rpm. Three runs were then made with satisfactory run-to-run and mode-to-mode agreement. Generally speaking plus or minus ten percent of the mean is acceptable with plus or minus five percent of the mean excellent test repeatability. There is no hard and fast rule since test repeatability is dependent on engine, procedure and exhaust contaminant.

Eight runs were made using the 23-mode procedure of which seven were used. The large number of runs were possible because of the delay in receiving additional engines for test. This allowed certain instruments to be checked for repeatability. HC, CO, NO_2, and aldehydes exhibited mode-to-mode variability (one run had to be discarded), but on an overall test brake specific basis, the run-to-run repeatability looked good. Little more can be

TABLE 9. EXPERIMENTAL 23-MODE PROCEDURE DRY CORRECTED EMISSION RESULTS

			Grams/Bhp-Hr					
Engine	Date	Run	HC	CO	NO_2 Obs.	Alde.	Cycle Weighted BSFC	Humidity gr/lb d.a.
2-1	3/8/72	2	12.17	53.0	12.0	-	0.750	61
2-1	3/8/72	3	11.02	49.2	12.4	-	0.750	55
2-1	3/9/72	1	9.50	40.7	13.4	0.130	0.750	44
2-1	3/9/72	2	9.16	46.4	13.4	-	0.748	59
2-1	3/10/72	1	9.11	46.4	11.2	0.125	0.750	73
2-1	3/13/72	1	9.50	47.7	10.2	-	0.750	94
2-1	3/13/72	2	9.88	51.3	10.9	-	0.750	101
	Average		10.05	47.8	11.9	0.127	0.750	
1-1	3/29/72	1	8.62	46.1	13.8	0.206	0.661	35
1-1	3/29/72	2	8.75	45.6	14.6	0.200	0.685	37
1-1	3/31/72	1	9.35	46.5	14.8	-	0.678	39
1-1	3/31/72	2	9.05	46.6	14.8	-	0.678	37
1-1	4/3/72	1	9.98	49.2	12.1	0.221	0.679	85
1-1	4/3/72	2	9.44	43.5	13.7	-	0.679	91
	Average		9.20	46.2	13.9	0.209	0.677	
1-2	4/7/72	1	11.98	58.6	10.5	0.295	0.675	116
1-2	4/10/72	1	13.61	41.6	13.3	0.289	0.675	114
1-2	4/10/72	2	12.68	42.4	14.5	0.256	0.675	104
1-2	4/11/72	1	13.12	44.6	12.8	-	0.674	109
	Average		12.85	46.8	12.8	0.280	0.675	
2-2	4/17/72	1	11.91	80.7	9.4	0.226	0.757	46
2-2	4/17/72	2	12.16	85.3	9.3	0.182	0.756	55
2-2	4/18/72	1	13.28	95.0	6.9	0.177	0.756	101
2-2	4/18/72	2	13.34	94.7	6.6	-	0.756	104
2-2	4/18/72	3	12.35	93.4	7.1	-	0.756	96
	Average		12.61	89.8	7.9	0.195	0.756	
1-3	4/27/72	2	12.56	39.6	11.1	0.196	0.719	91
1-3	4/28/72	1	13.69	35.6	11.7	0.176	0.733	97
1-3	4/28/72	2	13.34	32.3	11.7	0.190	0.733	106
1-3	5/1/72	1	13.03	36.1	10.8	-	0.733	118
1-3	5/1/72	2	12.88	35.3	11.6	-	0.733	111
	Average		13.10	35.8	11.4	0.187	0.730	

TABLE 9. EXPERIMENTAL 23-MODE PROCEDURE DRY CORRECTED EMISSION RESULTS (Cont'd)

Engine	Date	Run	Grams/Bhp-Hr. HC	CO	NO_2 Obs.	Alde.	Cycle Weighted BSFC	Humidity gr/lb d.a.
2-3	5/11/72	1	10.27	28.4	10.5	0.272	0.655	98
2-3	5/15/72	1	8.41	30.1	11.3	0.254	0.614	80
2-3	5/16/72	1	8.73	29.6	10.3	0.261	0.630	101
2-3	5/16/72	2	8.19	33.2	10.7	-	0.620	95
2-3	5/17/72	1	9.37	27.9	10.7	-	0.642	92
2-3	5/17/72	2	9.41	33.1	10.6	0.259	0.627	98
	Average		9.06	30.4	10.7	0.262	0.631	

said regarding the results other than the revised experimental procedure was operable and acceptable data was obtained.

(b) Engine 1-1: Testing of engine 1-1 was begun on March 21, 1972 by running the nine-mode tests. A full break-in was not required on this engine because it had been used previously by the manufacturer for emission test purposes. A short run of about 8 hours, however, was made to make sure everything was in order before testing began. Timing and idle speed were adjusted as specified to 6° BTDC at 600 rpm. Three nine-mode runs were made with fair repeatability and no problems were encountered.

Further testing of engine 1-1 utilizing the experimental 23-mode procedure was begun on March 29, 1972. As noted in a letter dated April 7, 1972, to the Project Officer, Mr. John McFadden, the low rpm portion of the 23-mode cycle was performed at 1300 rpm instead of 1200 rpm, because the engine would not hold steady loads at high power levels at the 1200 rpm speed. There was no appreciable vibration or noticeable malfunction of the engine i. e. misfiring, surging, etc. and no explanation can be offered at this time as to the difficulty encountered.

Although the overall brake specific results in Table 9 were repeatable from run-to-run, the individual mode repeatability was sometimes much less than the summary table would indicate. It was felt that this may be due to this specific engine, however, whatever the reason, we were concerned about some of the more-to-mode agreement for this engine. This phenomenon is expected during certain modes i. e. C. T. and idle, and light loads, especially at low speed. These modes have always been difficult to run and obtain highly repeatable values, ± 5 percent of the mean for example.

(c) Engine 1-2: After a short run-in, similar to engine 1-1, testing of engine 1-2 began on April 6, 1972. The nine-mode runs went smoothly with no problems. Summary Tables 7 and 8 show good repeatability for both the Federal Test Procedure concentration and mass results. Run 2 NO and NO_2 were low and Run 4 HC was high, but investigation has shown the runs were made properly and the values represent actual engine operation at that time and not a chart reading error or computation error.

The usual mode-to-mode variability of certain modes of the 23-mode procedure were experienced. When the calculations were made of the run composite, the variations in mode concentrations apparently have a self-compensating effect so that cycle results are quite comparable.

(d) Engine 2-2: Baseline runs for engine 2-2 began with the nine-mode test procedure on April 14, 1972. The three runs used went smoothly with no problems. The major point of interest with the 23-mode test was the difference in emission levels on different days. During a single day the mode-to-mode repeatability was good but the gross difference in weather between the 17th and 18th of April are felt to have influenced the emission levels of the engine. Both changes in barometer and inlet air humidity were significant as a result of a cold front.

On mode 13, the maximum power, 2300 rpm condition, CO went off scale and was greater than 11 percent full scale of the instrument. This occurred during each test. Since the instrument is routinely spanned to 11 percent CO at 100 percent chart deflection, this value was entered for the CO. Mode-to-mode repeatability appeared good for all the tests run including aldehydes which were more repeatable than usual.

(e) Engine 1-3: Testing of engine 1-3 began on April 24, 1972 when the nine-mode FTP tests were begun. The results were quite repeatable. The 23-mode results per Table 9 also show good repeatability on a run-to-run basis. The computer print-outs of the various tests did not show a good modal repeatability as the run-to-run results might have indicated. Several modes of the nine-mode tests look suspicious and steps were taken to check the strip charts for possible errors in reading.

The 23-mode results were acceptable on a mode-to-mode basis although some strange points were evident. Specifically, Run 2 on April 27, 1972, shows modes 9 and 14 (the 92 percent power modes) to have very high CO concentrations. This has happened before, with engine 1-2 made by the same manufacturer, and is felt to represent a transition point on the carburetor. Several times the various emissions would exhibit a string of high or low readings on a particular run. This is felt to represent actual engine performance as no errors were made in reading the emission levels.

(f) Engine 2-3: The nine-mode testing of engine 2-3 began on May 12, 1972 with no problems. The run-to-run repeatability was very good. The modal repeatability was felt to be satisfactory also. The overall 23-mode results also showed good run-to-run repeatability as seen in Table 9. The computer print-out sheets showed good modal repeatability as well. As with all the engines tested, the modal repeatability was not as good as the run-to-run repeatability on this engine, and also as usual, aldehyde measurement showed more variability than the other emission measurements.

4. Comparison of Nine-Mode and 23-Mode Emissions

Table 10 is a comparison of the average results obtained by the nine-mode and 23-mode test procedures for the six baseline engines. To facilitate the comparison, a comparison ratio (CR) was computed by dividing the 23-mode by the nine-mode brake specific emission rates. CR values greater than one indicate the 23 mode results were greater than the nine-mode. From Table 10, HC ratios ranged from 1.8 to 3.3, CO ratios ranged from 0.97 to 3.2 while NO_x ratios varied from 0.77 to 0.96. Although the two procedures result in essentially equivalent NO_x, the CO and HC range of variation does not justify direct comparison of the procedures.

TABLE 10. COMPARISON OF AVERAGE NINE-MODE AND 23 MODE RESULTS
Six Engine Baseline

Brake Specific Emission Rates, Grams per bhp-hour

Engine Code	HC			CO			NO_2		
	9 Mode	23 Mode	CR	9 Mode	23 Mode	CR	9 Mode	23 Mode	CR
2-1	3.15	10.05	3.3	14.77	47.8	3.2	14.48	11.92	0.82
1-1	3.07	9.20	3.0	18.27	46.2	2.5	14.42	13.94	0.96
1-2	7.33	12.85	1.8	32.6	46.8	1.4	14.00	12.78	0.91
2-2	5.70	12.61	2.2	69.2	89.8	1.3	10.11	7.87	0.77
1-3	4.53	13.10	2.9	15.8	35.8	2.3	12.22	11.38	0.93
2-3	3.36	9.06	2.7	31.4	30.4	0.97	11.20	10.69	0.95

Several other analyses were made to establish correlation between the two procedures with inconsistent results. No clear cut trends of agreement between procedures or prediction of say 23 mode from nine-mode results was evident from the data for the six 1972 baseline engines. Although beyond the scope of this project, there are probably several good reasons for this difference. One likely reason for the higher HC by the 23 mode test was the use of a lightly heated (160°F) FID for analysis instead of the NDIR sensitized to a paraffin, n hexane, used in the nine-mode. A factor of 1.8 is used in the mass calculation of nine-mode HC concentrations to compensate for this difference. The lightly heated FID also eliminates the cold trap required for NDIR analysis, where some HCs are lost.

One obvious reason for higher CO by the 23 mode procedure is that several high power conditions are included in the 23 mode that are not in the nine-mode schedule. These conditions, all typically at intake manifold vacuums less than 2.5 in. Hg. (adjacent to and including WOT operation), are producers of substantial quantities of CO. A third possible reason for the lack of agreement in HC and CO may be the large number of modes and weighting factors used in the 23 mode test relative to the nine-mode procedure. The origin of the 23 mode test schedule operating speeds, loads, and weighting factors was from a computer analysis of the original 1961 Ethyl truck and bus survey data. The computer analysis and subsequent formulation of the test schedule was performed by EPA's Procedural Development Branch, Division of Emission Control Technology.

The nine-mode test procedure was reportedly arrived at by the State of California Motor Vehicle Pollution Control Board, now known as the Air Resources Board, in conjunction with the Automobile Manufacturers Association and certain gasoline truck manufacturers. A direct comparison of the modes and weighting factors is not obvious. While the specific origin of and basis for the 23 mode test is known, the nine-mode procedure is mostly unknown. Although both procedures are engine exercises, the nine-mode test is recognized as much easier to design around than the 23 mode test. Neither include transients (acceleration-deceleration) and this is a shortcoming of simplistic engine speed-load emissions mapping procedures.

5. Computer Print-out of Modal Data

Appendixes A through F to this report contain computer print-outs for every run summarized in Tables 7, 8 and 9. One appendix is devoted to the baseline results for each engine and follows the chronological schedule of test, i. e., engine 2-1 is covered by Appendix A while Appendix F contains data for the last engine tested, number 2-3. Each appendix is subdivided into three sections, the first containing nine-mode concentrations, the middle section the California calculation of the nine-mode test in mass per bhp-hour, and the final section listing all the 23-mode run data obtained. To find a specific print-out for a given engine, locate the proper section of the respective appendix and then match up date and run number to that listed in the text summary table.

There is a substantial amount of data in these six appendices starting with raw, as-measured concentrations and ending up with weighted modal results. There are many ways this data may be useful and accordingly, full details are shown. For some print-outs, such as the Federal FTP mass and the 23 mode test, engine operating parameters of observed flywheel hp, fuel consumption, intake manifold vacuum are listed.

In the case of the 23-mode, grams of emissions per hour, are computed and shown. This is the best method for expression of mass rate for all modes. A cycle weighted brake specific fuel consumption (BSFC) is shown based on modal fuel and power readings. The same weighting factors used for emissions were used for BSFC. Modal air-fuel ratio was calculated and printed by the computer for Engine 2-3. The reader is referred to Appendixes A through F for the full data and particulars regarding the baseline test series.

B. Control Technology Assessment

The intent of the control technology phase of this project was not one of design and development, rather of screening, confirmation, evaluation and assessment both of laboratory run experiments at SwRI and data available from the manufacturer. In addition to the meetings held on January 13 and 14, 1972, with the two manufacturers, two additional separate meetings were held on March 7 and 15, 1972.

The specific objective of these meetings was to obtain advice and as many devices and equipment, parts, ideas, etc., as possible to make the in-depth study of future control technology as meaningful as possible. Some of the specific methods discussed were:

Exhaust Gas Recirculation (EGR) Internal-External
Spark Retard plus Oxidation Catalyst
Spark Retard plus Manifold Reactor
Lower Compression Ratio (add head gaskets)
Derate Engine by Using Smaller Carburetor
Electronic Fuel Injection (Open-Closed)
Capacitor Discharge Ignition
Variable Venturi Carburetor

Of course, there are many other possibilities and not all items on the above list were to be accommodated within the time and money constraints of the project. For example, electronic fuel injection holds promise, but requires development. Capacitor discharge will do little to reduce emissions from a new engine, but should go far in maintaining low emissions due to the improved durability of the equipment and lack of wear, etc.

Little in the way of data or experience was provided by the manufacturers with regard to making substantial improvements in emissions from their engines. The discussions also covered the usual concern about the relationship of laboratory engine results to driveability and durability. It was emphasized that this control technology project had to begin with laboratory studies which would have to be followed by studies of other aspects.

From the control technology standpoint and the availability of test results, etc., the meetings were not nearly as productive as hoped. Little was offered in the way of assistance by one manufacturer and only limited assistance was promised by the other. The representatives of both companies were sincere in wanting to be of help, but, since their major concern was passenger cars, they plainly could not offer much at that time in the program.

The general lack of technology in the industry required SwRI to respond quickly with control approaches that required little or no design and development. Within the desired time constraints, this limited the items for test to those normally used for light duty engines, such as oxidation catalysts, EGR, manifold air injection, etc. As soon as the full impact of these findings with the manufacturer was felt, the staff of the Emissions Research Laboratory, on the advice and consent of the Project Officer, began a series of contacts with the control equipment supply industry. Manufacturers and suppliers of EGR valves and control equipment, oxidation catalysts, oxidation-reduction catalysts, fuel injection systems, and turbochargers were contacted and where available samples obtained for consideration.

The time constraints of the project precluded the operation of many items since additional development would be necessary to adapt most of these components to the engine. Essentially no time or effort was available for such studies and optimization so that of all the items considered, only a popularly-used commercially-available precious metal type oxidation catalyst was selected for evaluation. A pair of platinum-type honeycomb catalytic reactors, as well as technical information and support, were obtained from the reactor manufacturer. These reactors were of a size that could be used with both control technology engines.

1. Engine 2-3 Control Technology Results

Conversations with the Project Officer on April 28, 1972, resulted in the test plan shown on Table 11 for the control technology assessment of engine 2-3. The test plan was not considered a rigorous parametric study in the classical sense in that one parameter is not always varied over the entire range of conditions at a time to determine effects singly. Engine timing experiments, Step 1, were parametric in nature as was step 5. Only one catalyst and one air pump system were considered. Clearly, there were too many dimensions of possible interest to investigate each singly, much less in all the possible combinations and permutations to meet the time and financial constraints of the project.

The plan was to explore possibilities of gross emission effects due to gross changes in engine operation. This approach was somewhat unconventional, but with only two months to complete the tests with engine 2-3, there was no alternative. As specified by the Project Officer, the experimental 23-mode test procedure was the primary basis for comparison of HC, CO, and NO_x emissions performance. A shortened version of this procedure was used in which mode times were reduced to approximately 1.5 minutes. This is sufficient time to obtain stable engine and emissions performance under most all operating modes.

(a) 1972 Versus 1973 Version Tests -

Prior to starting Step 1, the engine was operated in its 1973 California version with a different distributor, carburetor, carburetor air cleaner assembly and water thermostat. These items were furnished by the manufacturer and their installation and adjustment specifications strictly adhered to. Repeated 23-mode runs were made with the 1973 version of the engine with emission rates of CO substantially higher and NO_x substantially lower than the 1972 basic engine. These results are summarized below and the computer run sheets included in Appendix G.

Engine 2-3. Experimental 23 Mode Mass Emission Rates, grams per bhp-hr (Army Laboratory)

	CO	HC	NO_x
1972 Baseline Engine	30.4	9.06	10.69
1973 California Configuration	70.77	10.09	5.82
1972 Engine (Retest)	33.37	8.54	11.57

TABLE 11. PLAN OF TEST, ENGINE 2-3

Step	Description
1	Convert Engine to 1973 California version and vary basic timing, i.e., say 10° and 5° advanced, standard and 5° and 10° retarded timing.
2	Install larger and smaller carburetor jets to modify engine air-fuel ratio at standard timing.
3	Install air pump system and run engine at standard timing and one extreme each side of standard.
4	Install standard EGR system and run at standard timing and one extreme advanced and retarded timing. Use standard engine with the air pump off.
5	Investigate modified EGR, i.e., other flow rates at various modes.
6	Install catalytic reactors, clean fuel system, and run with and without air pump at standard timing advanced and/or retarded (operate on clear fuel unleaded) run longer modes and sample exhaust before and after catalysts.
7	Carburetor modification - derate engine by running with two large barrels of 4 barrel carburetor blocked. Standard engine otherwise.
8	Combine best EGR with best air pump - catalyst-ignition timing found in Steps 2, 3, and 4.
9	Investigate other combinations of the above or control approaches as they develop.

The higher CO and lower NO_x with the 1973 engine on the 23-mode test are unexplained although the run-to-run agreement for each series of tests was satisfactory and the changes were real. Several runs were made with the engine returned to its 1972 standard configuration to verify the large differences in CO and NO_x. The baseline (six tests) and retest data were in agreement.

Although the 23-mode test schedule was established by the Project Officer as the test procedure for use in control technology assessment, it was felt of interest to determine what the engine would emit on the nine-mode schedule both in concentration by the current FTP and in mass by the 1974

FTP. It is the latter which applies to gasoline engines in heavy duty service in California beginning in 1973 and nationwide beginning in 1974. These results are summarized below:

Engine 2-3, Nine-Mode FTP Concentration Results

	HC, ppm n Hex.	CO, %	NO*, ppm
1972 Standard Engine (Baseline)	116	0.66	1601
1973 California Configuration	88	0.78	971

*Corrected to 75 grains humidity

Engine 2-3, Nine-Mode 1974 FTP Mass Results, grams/bhp-hr

	CO	HC	NO_x*	HC + NO_x
1972 Standard Engine	31.4	3.36	11.20	14.56
1973 California Configuration	33.73	2.57	6.59	9.15

*Corrected to 75 grains humidity

Based on the nine-mode schedule, the difference in emissions between the 1973 and 1972 engines were much less than earlier shown on the 23-mode except in NO_x. The only good explanation is that an engine calibrated for a schedule incorporating only six different modes (nine-mode FTP) may result in a quite different conclusion if operated on a schedule comprising many more modes such as the 23-mode schedule where 21 different modes are employed. Note, only 15 different modes are used in the calculations since some modes had a zero weighting factor. Of course, weighting factors, choice of power levels and, to a much lesser extent, engine rpm play important parts in establishing an engine's total emission rate.

It may be noted that the 1973 California configuration brought the engine's HC+NO_x well below the 1973 California and 1974 Federal limit of 16 grams per bhp-hr without materially changing CO which was below the 1973 limit of 40 grams per bhp-hour. To this end, the 1973 version is considered an improvement over the 1972 engine. The 23-mode procedure, an experimental method, yields a much different conclusion in terms of CO and NO_x. Run data for this series of tests are included in Appendix G of this report for further analysis on a mode-by-mode basis, etc. The conclusion from this series of tests was to utilize the 1972 standard engine as the basis for control technology assessment. In effect, these experiments indicate that changing back from 1973 to 1972 would be an important improvement in exhaust pollution from this engine, based on the 23-mode tests.

The arrangements for use of Cell 3 of the U. S. Army Fuels and Lubricants Laboratory called for release of this facility on June 1, 1972. Accordingly, the test efforts were transferred to the Emissions Laboratory on June 1, but not before all items of equipment, dynamometer, etc., were checked and recalibrated. Power curves were run at several speeds with engine 2-3 to ensure the new facility dynamometer power and speed read-outs would be identical to that previously used. After several days of work, the physical installation was completed and the dynamometer in operation. Power, speed, fuel, manifold vacuum and other physical operating characteristics were replicated and operation of the engine was found to be essentially identical to the previous location.

Before continuing with the control technology phase of the project, several more days were used to rerun the 1972 and 1973 engine version 23-mode tests discussed earlier. These results are summarized below and show close to the same magnitude of difference between 1972 and 1973 engines.

Engine 2-3. Experimental 23 Mode Mass Emission Rates, grams per bhp-hr (Emissions Laboratory)

	CO	HC	NO_x
1972 Baseline Engine	56.20	7.01	8.60
1973 California Configuration	72.40	8.22	6.61

The 1973 version of the engine repeated the tests made earlier in the Army Laboratory with CO 72.4 versus 70.77, HC 8.22 versus 10.09 and NO_x 6.61 versus 5.82. Trendwise the 1972 engine was still better than the 1973 engine per the 23-mode test, but the 1972 engine data were not as close to earlier 1972 data as desired.

The same instruments, sampling system and fairly similar exhaust piping, muffler, etc., were used. The same emissions test fuel, exhaust restriction and calibration, span and zero gases were used. The engine was not damaged or altered in making the move and to date, no really good explanation for the differences in 1972 emission rates has been found.

In the last part of Appendix G may be found the 23-mode computer print-out sheets. Comparing the modal data for these runs against that from the earlier data, also in Appendix G, obtained in the original installation, reveals that the differences are predominately in the light load portion of the schedule. This is, of course, one of the big contributors of HC and is the most difficult part of the 23-mode schedule to operate.

In summary, no really satisfactory explanation of the difference in Army Lab 1972 and Emissions Lab 1972 data could be found. The good repeatability for the 1973 version of the engine indicates that the test location, procedure, etc., was not necessarily the cause.

(b) Step 1 - Effect of Timing

The intent of this series was to determine what effect gross changes in basic engine spark timing would have on emissions and performance. In running these tests, the 1972 engine was used and the basic distributor timing set at 25° BTDC, 16°BTDC, standard timing (4°BTDC), 4°ATDC and 12°ATDC. The results are summarized on Figure 5 and are 23-mode composite data on a grams per bhp-hour basis. Setting the timing later and later resulted in a nearly uniform decrease in NO_2, the greatest reduction occurring between 15°BTDC and 4°ATDC. This same range had the opposite effect on CO, however, with about a 35 percent increase in CO between 15°BTDC and 4°ATDC range.

HC increased greatly between 4°ATDC and 12°ATDC indicating a loss in combustion efficiency. Settings of 25°BTDC and 12°ATDC represent the approximate advance and retard limits of the engine as far as engine operation was concerned. Cycle weighted BSFC is also plotted on Figure 7 as an indication of the effect of timing on fuel consumption and economy. Note the effect of retarded timing on cycle BSFC with a significant loss in economy of operation shown at 4 and 12°ATDC.

Appendix H contains tabular, computer print-out, data for modal analysis and plots of the data. Figures H-1, H-2, and H-3 show the effect of power on the mass rate, grams per hour for HC, CO and NO_x as NO_2. Also plotted are the 1973 California configuration modal results (from data in Appendix G) for comparison to the 1972 standard engine. By oversight, one run at 12°ATDC was made with the distributor vacuum advance line disconnected. The run was valid otherwise and the results are plotted for general information. Both 1200 rpm, broken line, and 2300 rpm, solid line data are plotted. Also shown are closed throttle (CT) and idle results.

Figures H-4 and H-5 of Appendix H are similar plots of engine intake manifold vacuum and fuel consumption. Other plots of the data in the Appendix H computer print-outs could be made such as power versus emissions on a brake specific or concentration basis. Plots of air-fuel ratio versus certain of the emissions would also be informative. In summary, retarding the spark 4 to 8 degrees from manufacturers standard timing of 4° BTDC would reduce both HC and NO_x with an increase in CO. Assuming performance is not jeopardized too much, this might be considered in conjunction with other approaches, especially one that reduces CO.

The importance of the closed throttle mode on HC production and its effect on the 23-mode result is dramatic. The two closed throttles are given 18 percent of the weight (12 percent at 2300 rpm and 6 percent at 1200 rpm). Any device or approach that can substantially reduce concentrations, nominally 30,000 to 90,000 ppmC, during these modes can have a noticeable influence on the final results.

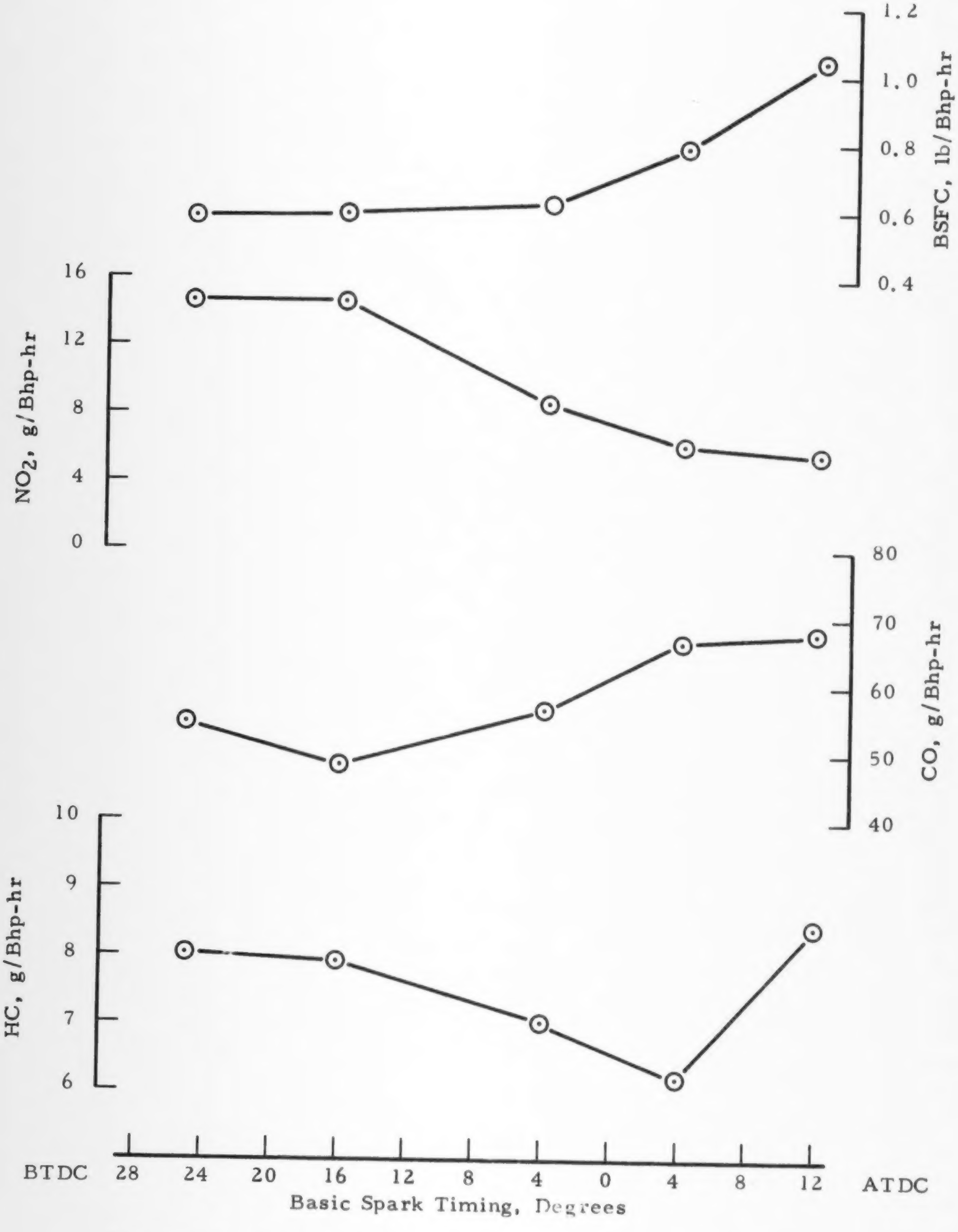


FIGURE 5. EFFECT OF SPARK TIMING ON EMISSIONS
ENGINE 2-3, 23 MODE TEST

(c) Step 2 - Effect of Air-Fuel Ratio

The usual way to investigate the effect of air-fuel ratio is to run tests with the main metering system modified to admit more or less fuel for a given air flow requirement. Several main metering jet and metering rod combinations shown in Figure 6 were furnished by the manufacturer and experimented with. The air-fuel ratio was determined for each of the 23 modes using the "Spindt Method" of calculation. From the modal air-fuel ratios, an overall "weighted air-fuel ratio" for the entire 23-mode test was computed using the modal weighting factors.

Figure 7 is a summary plot of the 23-mode results with the various jet-rod combinations. Also shown are the various size jets that were larger or smaller than the standard 0.073 inch jet, 0.0368 inch rod, combination. Note the plots of NO_x, CO and HC show that the mixture has an important effect on emissions. The trends of lower NO_x and higher HC and CO as air-fuel mixture becomes richer with fuel was as expected. The dramatic increase in CO was not unexpected based on our experience with a number of in-service gasoline trucks. On the fuel lean side, the 1972 engine was not too far from its "lean limit" as noted by the attempted operation of the engine with very small jets (0.064 inch). Weighted BSFC seemed little affected by the change in air-fuel ratio except at the rich mixtures.

Appendix I contains the computer sheets listing the modal results for this series of experiments. The gram per hour emission rate has been plotted against percent power for the several modes included in the 23-mode test. Grams per hour was selected as the primary expression since all modes have such a rate. Grams per bhp-hour is not applicable or appropriate where no usable load is obtained as in idle, closed throttle and very light load, i.e., 0-2 percent power. Concentration results, on the other hand, may be misleading since they do not include the air flow and thereby lack the direct contribution to the cycle result where mass rate is important.

Appendix Figures I-1, I-2, and I-3 portray HC, CO and NO_x as NO_2 in this way and are similar in appearance, but not in trend, to those in Appendix H for the effect of timing. Figures I-4 and I-5 show manifold vacuum and fuel consumption as a function of the power output. Time has not permitted further graphing and analysis of the results, although more could be done in this regard. In summary, this series of experiments confirmed the effect of air-fuel ratio on carbureted gasoline engines; namely, that richening the mixture with fuel reduces NO_x at the great expense of increasing CO and HC, as well as fuel consumption. As with the study of spark timing, this is another item which should be considered with after-treatment approaches such as air injection with or without catalysis.

(d) Step 3 - Effect of Exhaust Manifold Air Injection

Engine 2-3 was fitted with the factory exhaust manifold reaction

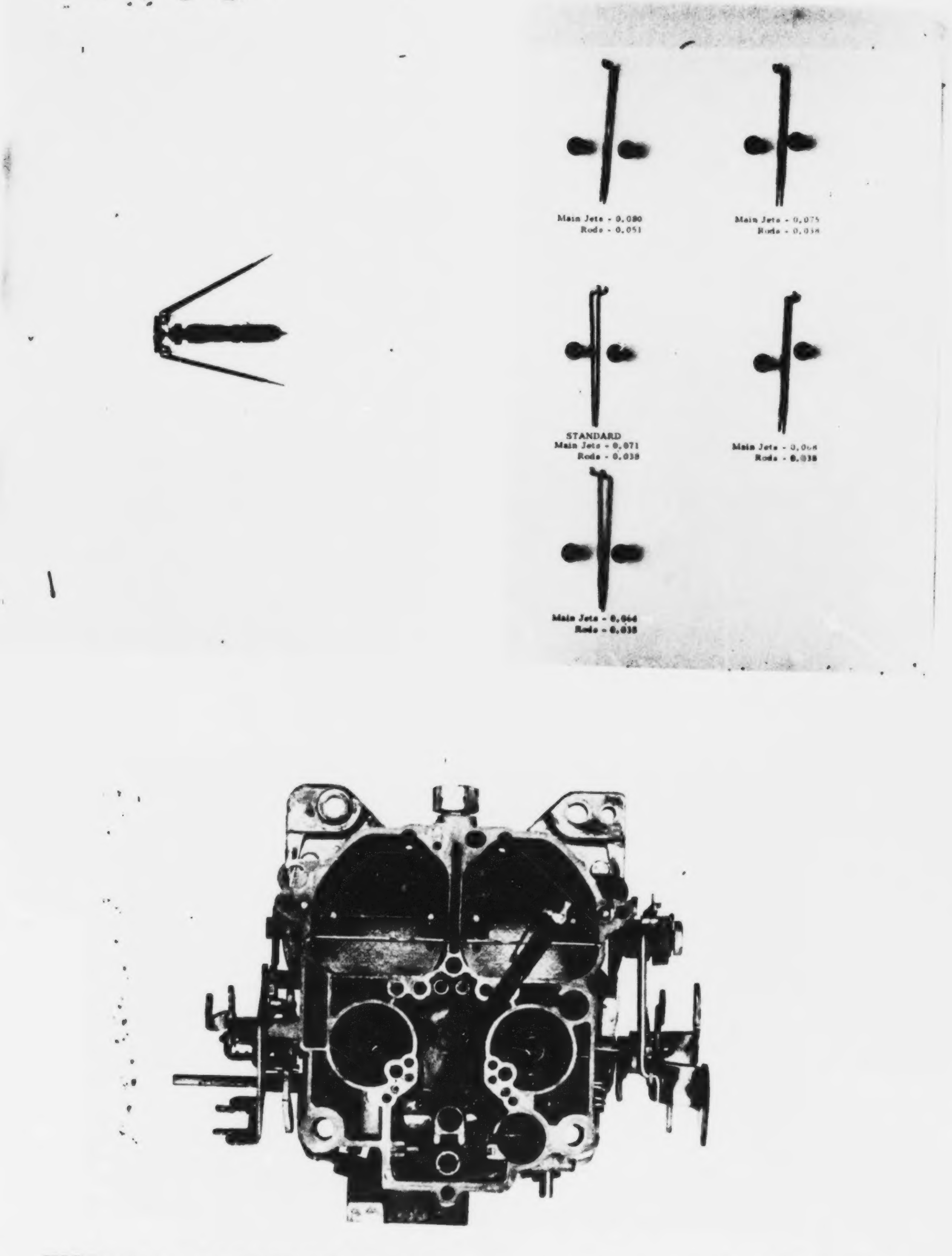

Main Jets - 0,080
Rods - 0,051
Main Jets - 0,075
Rods - 0,038
STANDARD
Main Jets - 0,071
Rods - 0,038
Main Jets - 0,068
Rods - 0,038
Main Jets - 0,064
Rods - 0,038

FIGURE 6. CARBURETOR RODS, JETS, AND THEIR LOCATION (ENGINE 2-3)

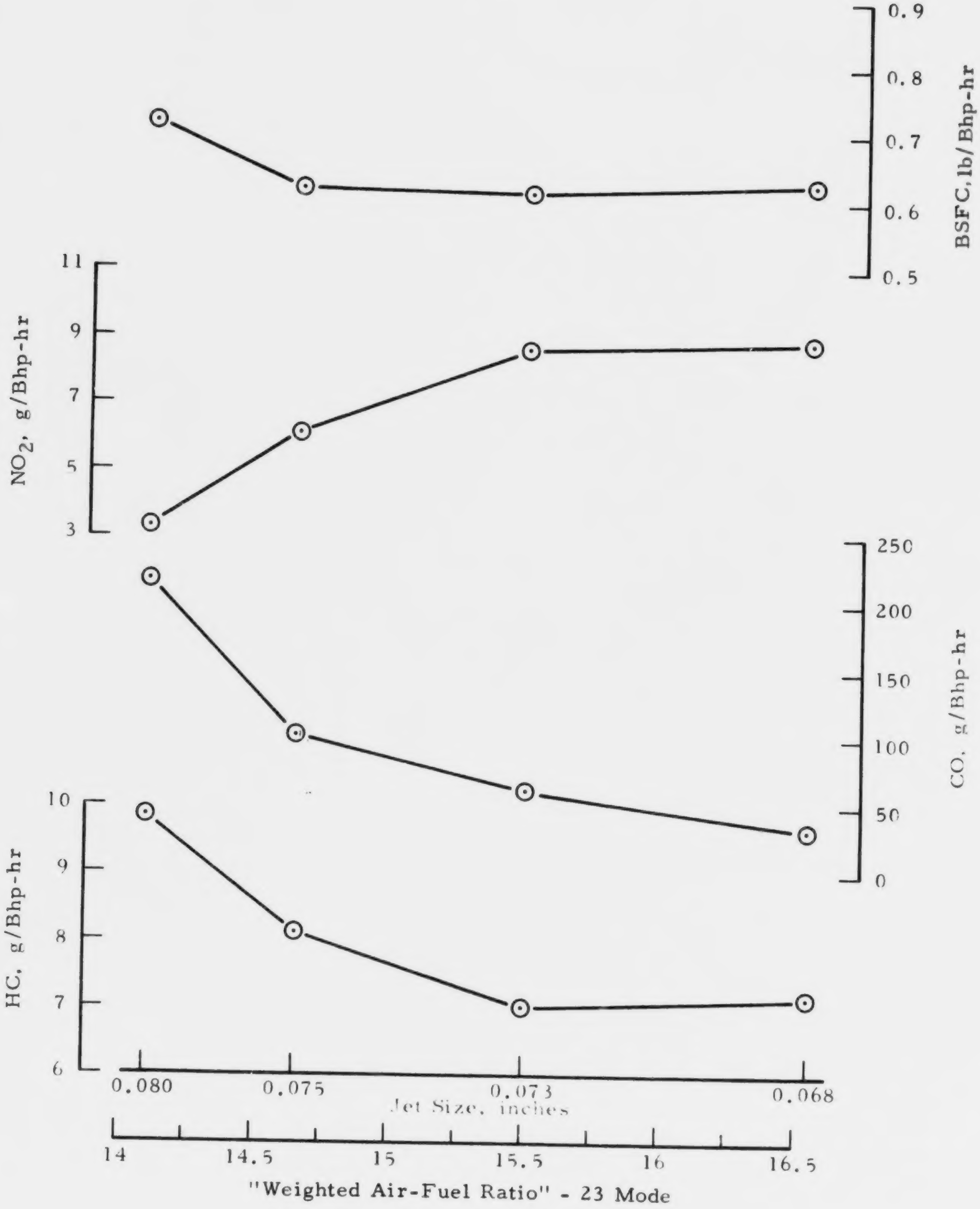


FIGURE 7. EFFECT OF AIR-FUEL RATIO ON EMISSIONS ENGINE 2-3, 23 MODE TEST

equipment, as shown in Figure 8. This involved replacing exhaust manifolds and installing air pump, belt, pulleys and required lines, fittings and injection tubes, so that air is admitted on the exhaust valve tulip. Several 23-mode runs were made at various basic injection timing settings including standard (4°BTDC), advanced settings of 16 and 25°BTDC and a retarded setting of 4°ATDC. The computer print-outs for this series of tests are included as Appendix J.

The grams per bhp-hr 23-mode results for HC, CO and NO_x and weighted BSFC are depicted on Figure 9. Also shown are the standard engine emissions versus timing for comparison. The brake specific NO_x emission values show little variation with timing that are not due to timing alone. And, relative to the engine run without air, the influence of air injection on HC is somewhat disappointing. Air injection did seem to reduce CO, however, especially at the standard 4°BTDC and at 4°ATDC.

Part of the explanation may lie in the large weighting given idle, closed throttle and light loads where exhaust oxidation would have a limited effect. Recall that the air injection acts as a diluent as well as a source for oxygen and that the diluent effect, which reduces concentrations, does not reduce emissions on a mass basis. Appendix J contains modal plots, Figures J-1 through J-5, of the run results for HC, CO, and NO_x, manifold vacuum and fuel consumption as a function of power level. Please refer to these plots for further insight on the effect of exhaust manifold oxidation by injected air.

(e) Step 4 - Effect of Light Duty EGR System on Emissions

This series of experiments required an experimental intake manifold furnished by the manufacturer that had been machined and prepared for exhaust gas recirculation from the exhaust heat crossover back to a central point in the intake manifold directly below the carburetor. The EGR is routed completely internal within the intake manifold and all that shows is a valve and the valve control vacuum hose that connects to the distributor vacuum line. Photographs of this system are shown in Figure 10. The system as used was the same as used in light duty vehicles and was installed and operated according to manufacturer's recommendations. The EGR rate was essentially zero, from 0 to 2 inches intake vacuum and constant at approximately 1 lb per minute above 8 inches of vacuum. The EGR rate increased in a nearly linear fashion between 2 and 8 inches of H_2O vacuum.

As with other similar studies, a series of 23-mode experiments was made at basic timing of 25, 16, and 4 (standard) °BTDC and 4°ATDC. The 23-mode composite results are also plotted on Figure 9 along with the standard engine without light duty EGR for comparison. Note that EGR is most effective on reducing NO_x at advanced settings where maximum NO_x was produced. To optimize the EGR as far as basic timing is concerned, it seems that a 4°ATDC or 8° retard from standard, results in the lowest

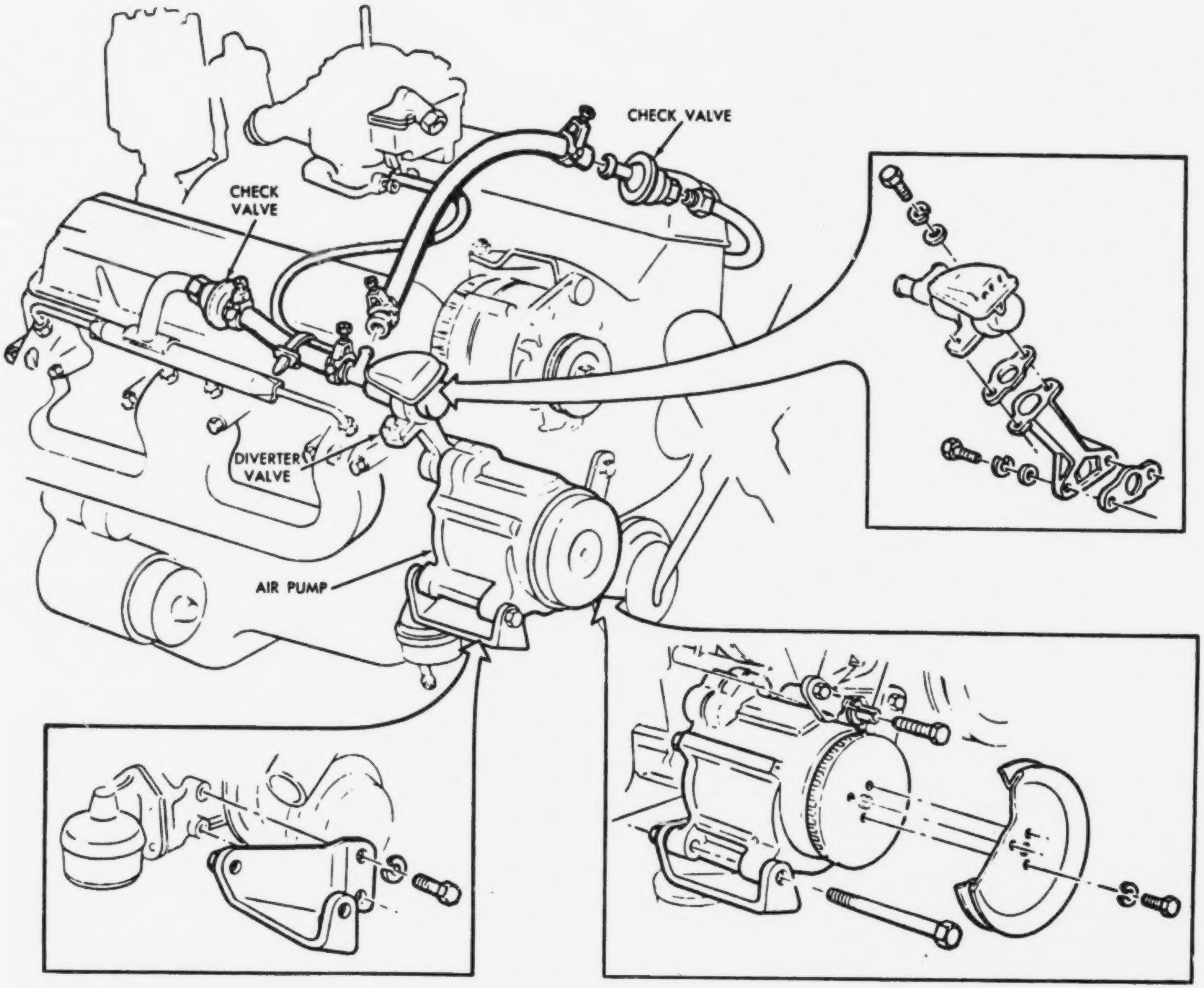

CHECK VALVE
CHECK VALVE
DIVERTER VALVE
AIR PUMP

FIGURE 8. EXHAUST MANIFOLD AIR INJECTION EQUIPMENT

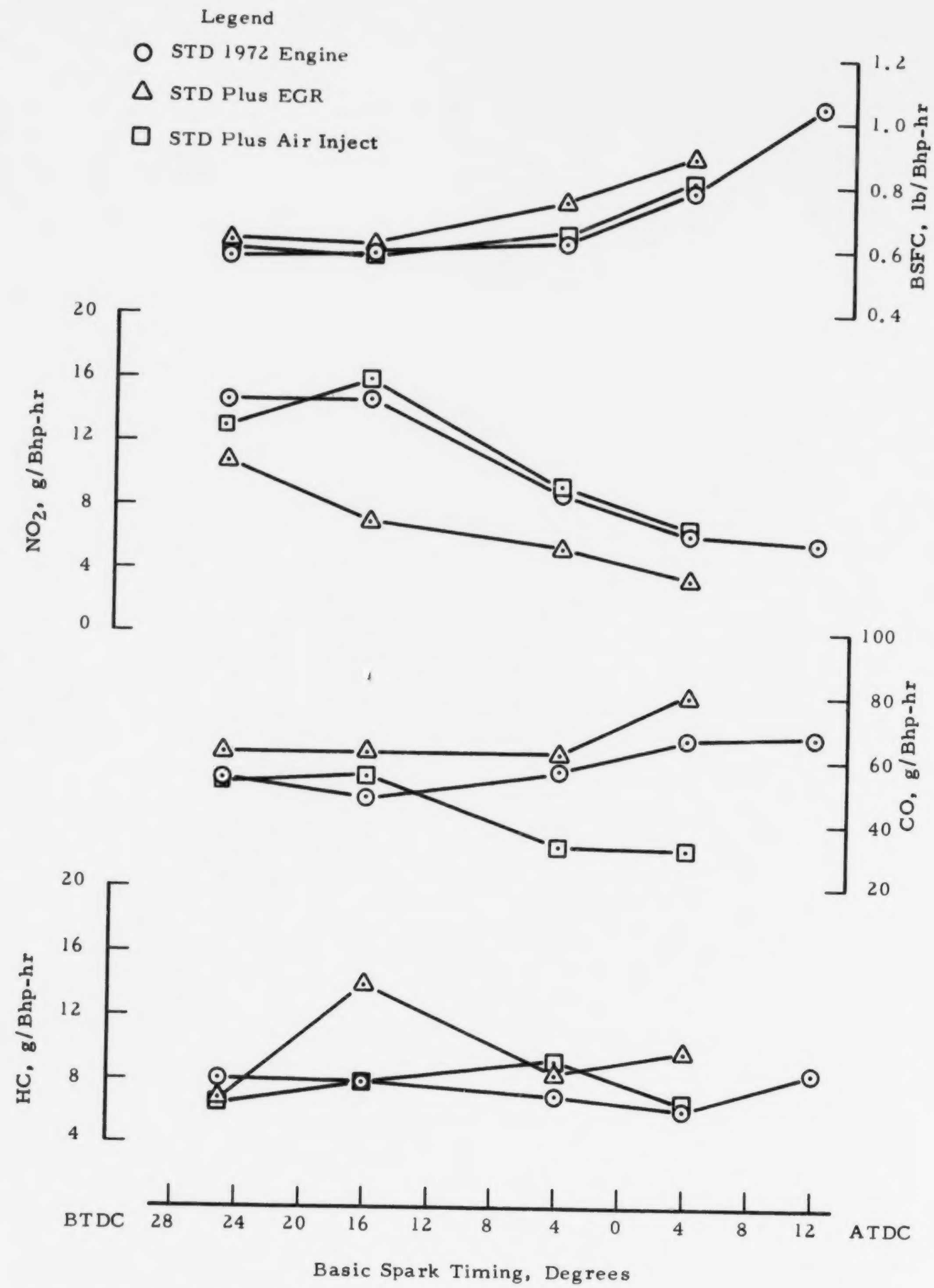


FIGURE 9. EFFECT OF LIGHT DUTY EGR AND AIR INJECTION ON EMISSIONS, ENGINE 2-3, 23 MODE TEST

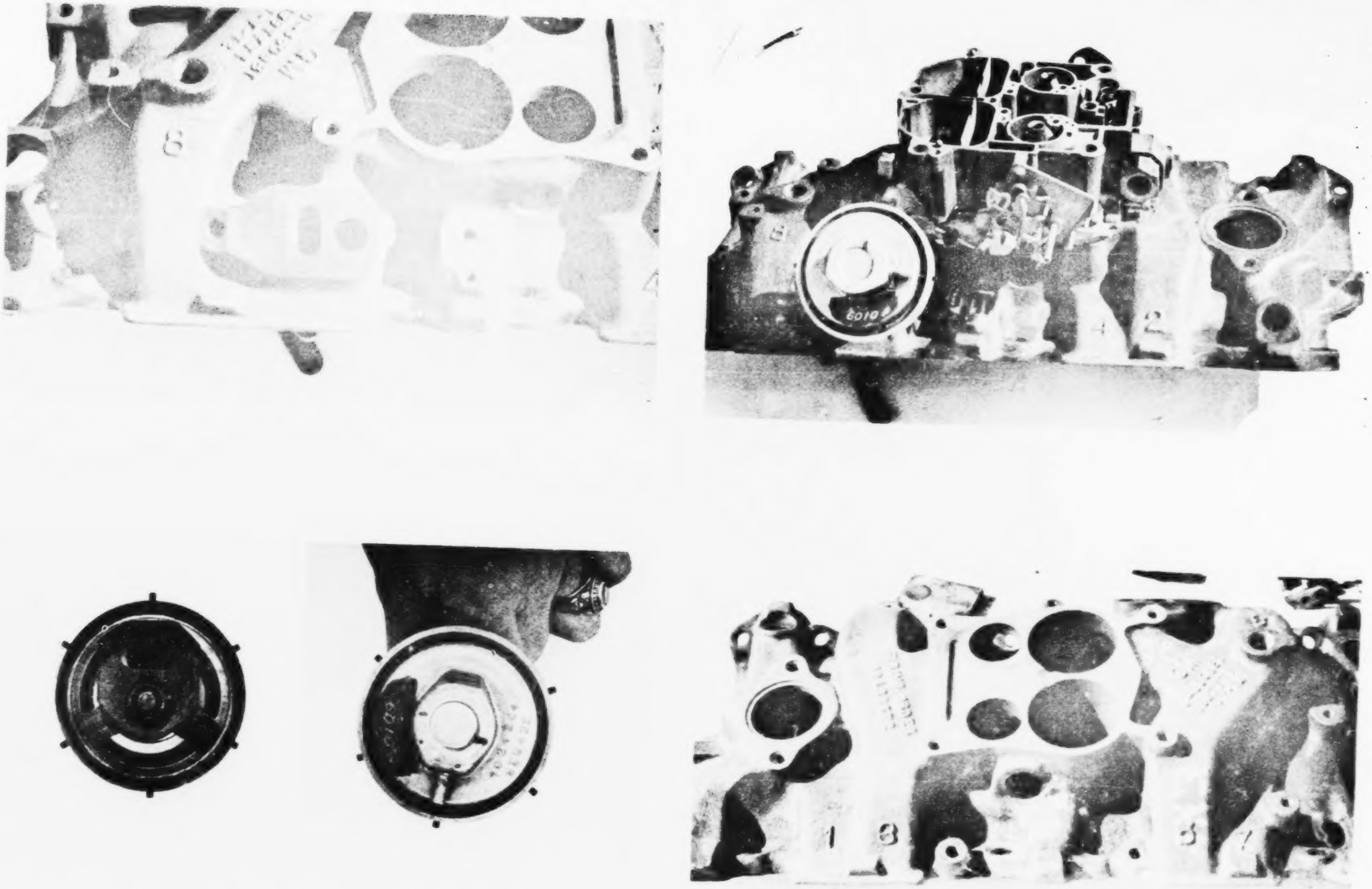


FIGURE 10. LIGHT DUTY EGR EQUIPMENT

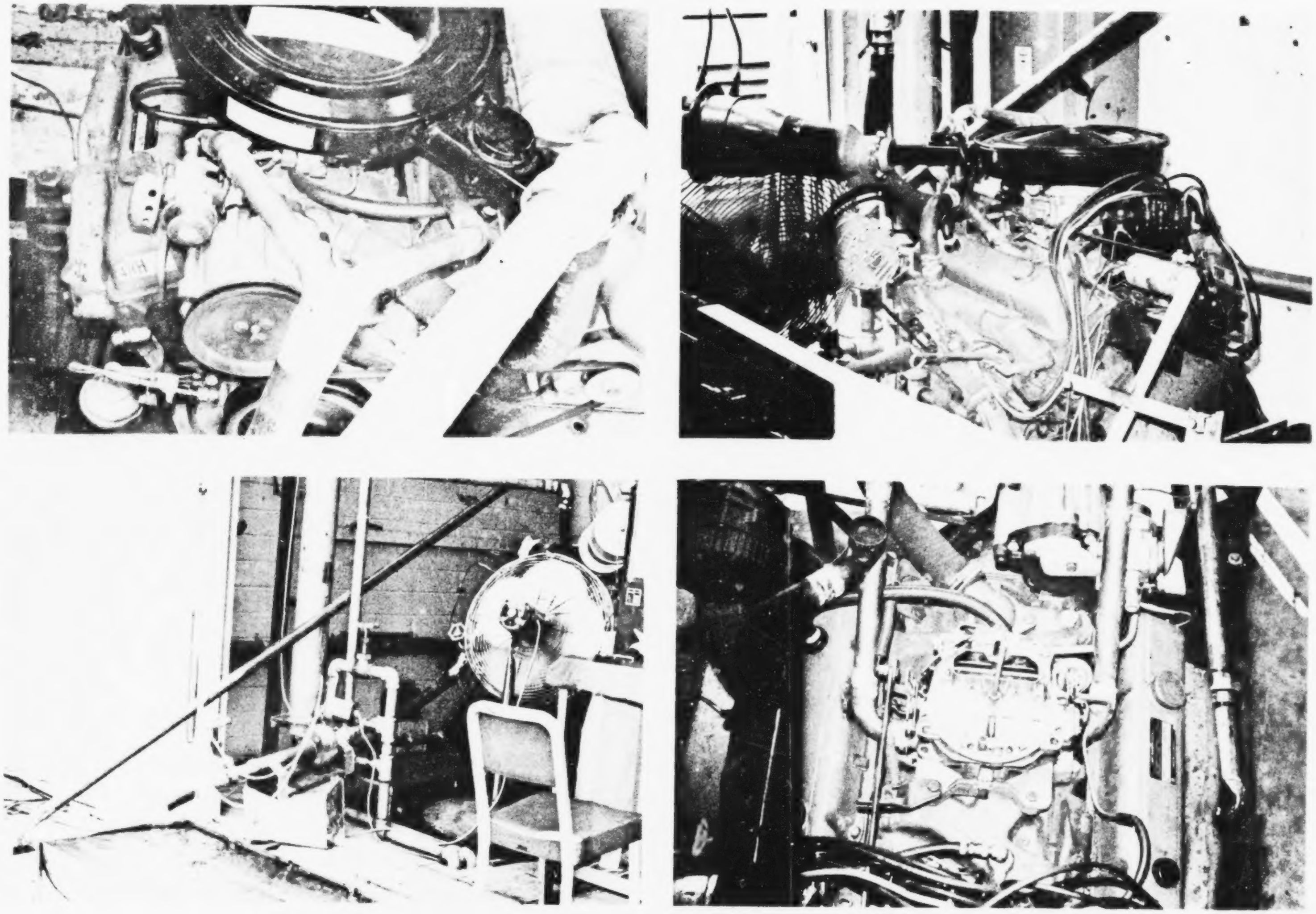


FIGURE 11. LABORATORY EGR SYSTEM

NO_x of about 4 grams per bhp-hr.

This is not necessarily the best operating point for CO, however, as shown on Figure 9, since this gives the maximum CO. HC, like CO, was adversely affected, i.e., increased by EGR throughout the range of timing studied, and , like CO, 4° ATDC was not the best setting for HC. It may be that in combination with other control approaches, the 4°ATDC will emerge as a possible operating point.

Appendix K contains the tabular computer print-out sheets and graphed results on a modal basis for the series of tests on the light duty EGR system. Please refer to these for additional detail or if a more thorough analysis is desired.

(f) Step 5 - Effect of Laboratory EGR on Emissions

This step was originally intended to involve tests at a given basic timing, such as standard, with a flow of exhaust modified from the light duty flow schedule. The light duty valve recirculates exhaust based on signal pressure from the distributor manifold vacuum line. On inspection of the flow capacity, it was found that even operating at maximum signal pressure the EGR rate would not give the desired flow for this step of the project.

To investigate EGR more fully, a laboratory EGR system was prepared that split-off some of the exhaust from the tailpipe at a point downstream of the muffler. The exhaust then passed through a simple two-pass single large tube air-to-water-heat exchanger and then through a flow measuring section thin plate orifice, a manual, gate type, control valve and then to the intake manifold.

The system shown in Figure 11 was designed to permit EGR at a specified flow in percent of carburetor intake air flow rate at 5, 10, 15, and 20 percent. These tests were made with the air injection system inoperative. The heat exchanger was a low pressure drop simple two-pass unit made hurriedly from 2-inch steel exhaust pipe with a total length of 18 ft. The outlet temperature was on the order of 95 to 100°F and represented what might be possible with a good air-to-air heat exchanger on a moderately cool day.

The return of the exhaust into the intake manifold was through two 3/4" pipe openings (1.05 inch ID opening in manifold). It is known that the distribution and mixing, etc., of recycled exhaust with the carbureted fuel-air mixture is tricky and requires substantial effort to perfect. In the very short time available, it was decided to add another 3/4" pipe opening directly across from the one already machined in the experimental manifold used as an access for internal machining for the factory EGR. The system was leak-checked and found satisfactory for a preliminary evaluation of EGR on the engine by the 23-mode schedule. It was a laboratory system used strictly for basic experimental purposes.

The results, all obtained at standard timing of 4° BTDC with standard carburetor, etc., are plotted in Figure 12 for EGR at various percentages of total engine requirement defined as:

$$\text{Percent EGR} = \frac{\text{EGR (SCFM)} \times 100\%}{\text{Total Flow Requirement (SCFM)}}$$

$$= \frac{\text{EGR (SCFM)} \times 100\%}{\text{Carburetor Air (SCFM)} + \text{EGR (SCFM)}}$$

The results are reduced to the 23-mode values, plotted in Figure 12, using the carbon balance method that has been employed throughout this project to determine exhaust mass rate. Recall that carbon bearing compounds, such as HC, CO, and CO_2 and fuel input are necessary measurements for this computation method. It can be shown, though it is not necessarily obvious, that this method will determine the mass of exhaust products exhausted into the atmosphere even though some of the exhaust is recirculated. The method is valid if the recirculated exhaust is admitted after the carburetor and throttle plate. It should be understood that EGR can reduce the mass of exhaust products emitted to the atmosphere. For example, at wide open throttle and constant speed, the mass flow rate of emissions can be less even though the concentrations of HC and CO are not reduced.

From Figure 12 the laboratory EGR was found to be quite effective on reducing NO_x. At about 10 percent EGR, the benefits of increased EGR are more than offset by the apparent steep increases in emission rates of HC and CO. Though 10 percent EGR was not necessarily optimum, it is probably in this vicinity that best NO_x control results under the 23-mode schedule. Above 10 percent EGR, the engine, at 1200 rpm, would not run when the power level was about 75 percent (15 percent EGR) and 50 percent load (20 percent EGR).

It is interesting to follow the effect of EGR on brake specific fuel consumption and on maximum power output. These results are summarized below. The cycle weighted BSFC results are also plotted on Figure 12. The BSFC and power loss at 10 percent EGR is substantial relative to no

Percent EGR	Overall BSFC 23-Mode Weighted	Power Output, Max bhp, Obs	
		1200 rpm	2300 rpm
0	0.648	52	108
5	0.681	50	99
10	0.750	47	88
15	0.915	42	78
20	1.075	35	67

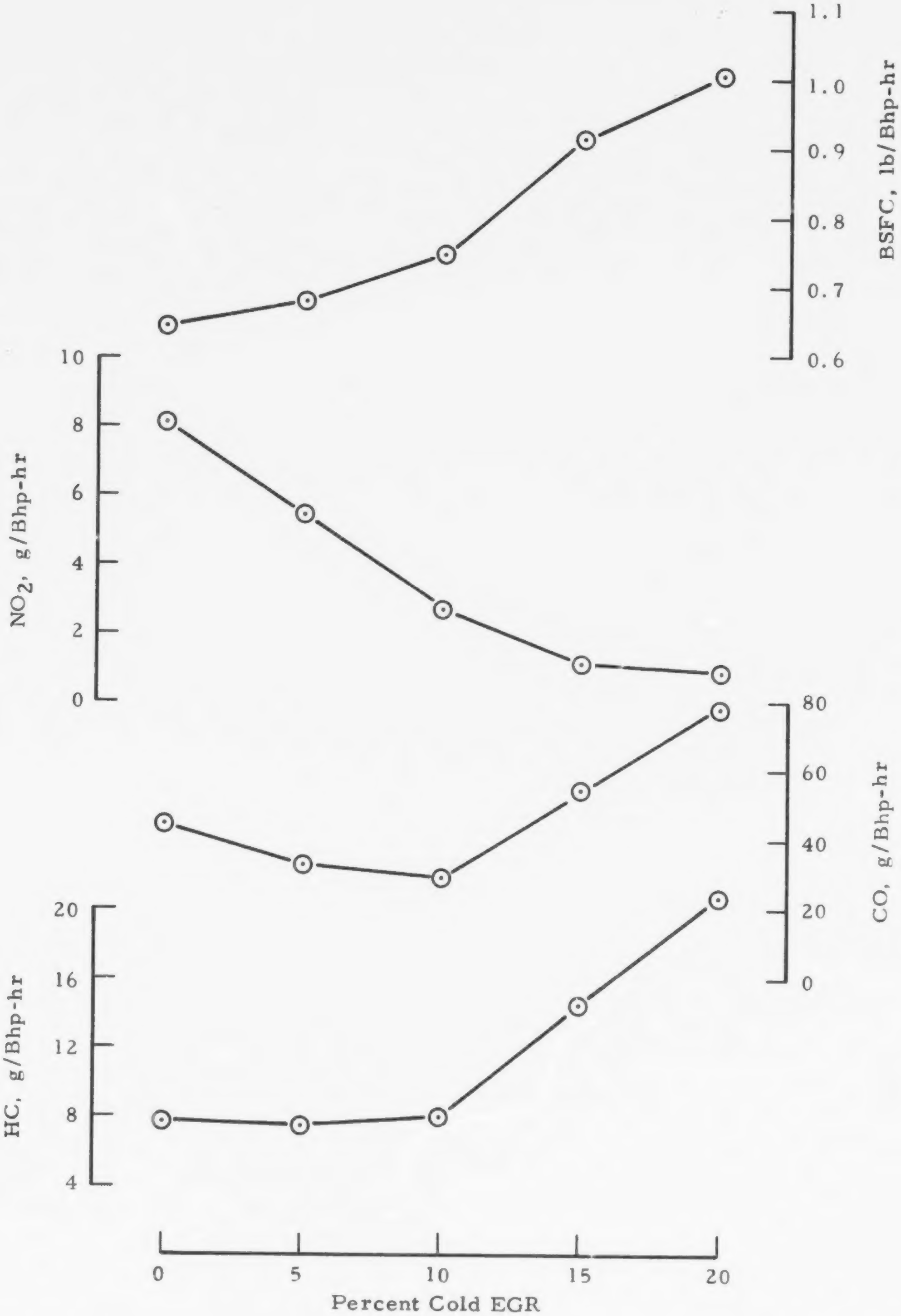


FIGURE 12. EFFECT OF LABORATORY COLD EGR ON EMISSIONS
ENGINE 2-3, 23 MODE TEST

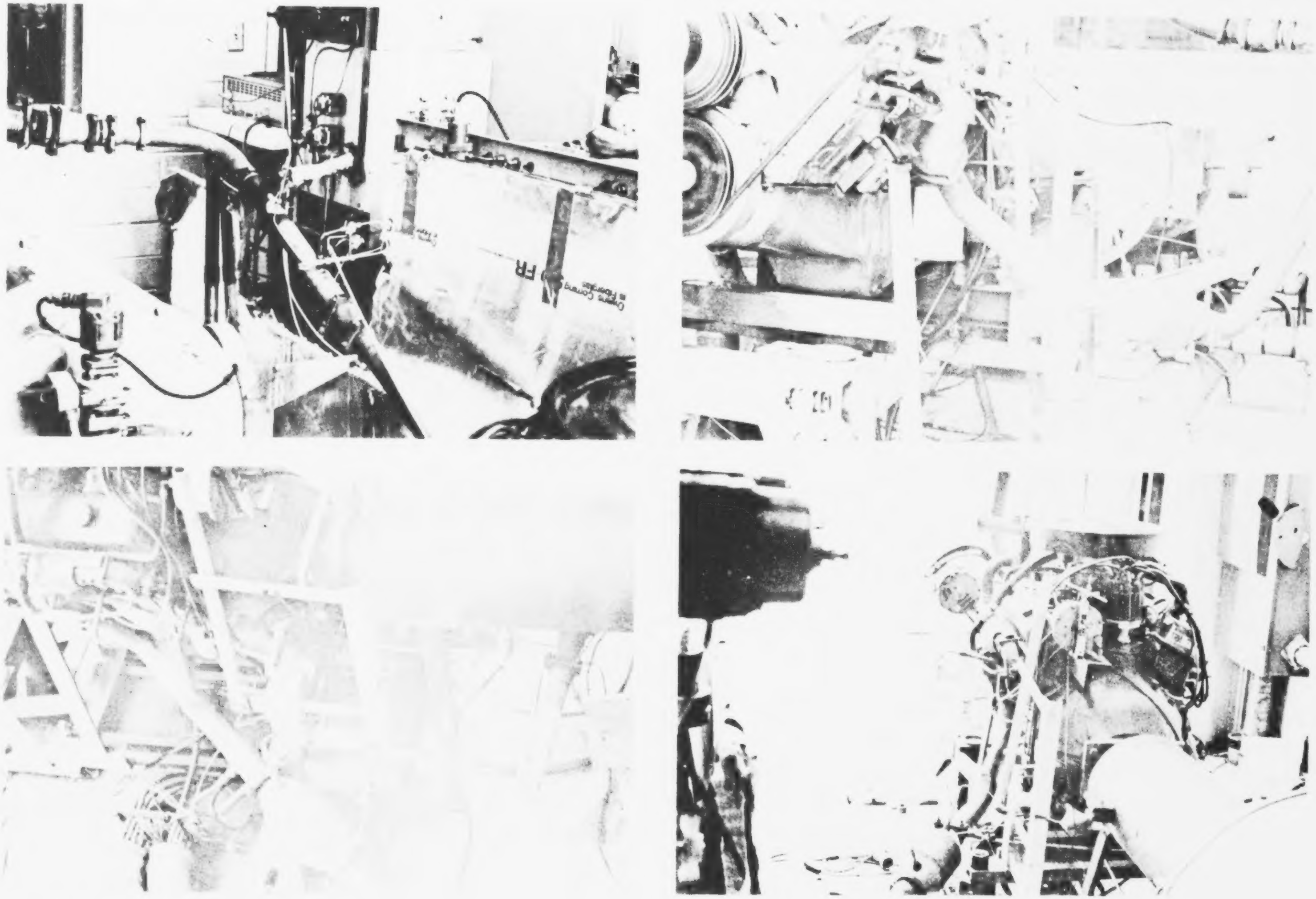


FIGURE 13. OXIDATION CATALYST TEST SET-UP
ENGINE 2-3

EGR. The maximum power could be restored by eliminating EGR at WOT. This will help BSFC only slightly however, since BSFC is a weighted value per the 23-mode test.

The results of this series of tests are included in Appendix L both in tabular and graphical form. Please refer to this Appendix for additional details. In conclusion, no tests were made to optimize for best performance taking into account fuel economy, brake specific fuel consumption, and driveability aspects such as roughness, misfiring, etc. It does point toward the possible benefits of EGR and illustrates what EGR might do for emissions from this size and make engine on a 23-mode or engine exercise type test schedule.

From the modal results in Appendix L, it is possible to select an EGR schedule that is optimum for NO_x that, in combination with other systems to remove CO and HC, could be driveable. The time limitations of this project have prevented this from being done on an engine. The results may be predicted, however, from data at various timing, air injection, carburetor settings with and without oxidation catalyst. Some combination effects may be seen from factory EGR plus catalysts and air injection at modified spark timing to allow a reasonable prediction.

(g) Step 6 - Effect of an Oxidation Catalyst on Emissions

This series of tests were made with Indolene clear, a well known American Oil Company low lead fuel that is a laboratory standard fuel for operation of devices such as catalytic mufflers. To prepare for these tests, a new fuel pump and fuel handling system up to the carburetor was installed and the carburetor bowl drained. A gallon of Indolene clear was run through the engine before the catalysts were installed. The exhaust system was replaced with new pipe such that the inlet of each of the two catalytic devices were located twenty inches from the exhaust manifold outlet flange. The dual exhausts were then joined together into a single exhaust. The conventional stock muffler was removed.

Samples were obtained from the exhaust at a point five feet downstream for analysis. A common sample of the gases as they entered the devices was obtained at a point one inch before each catalyst and these two samples "Teed" together to obtain a common sample for analysis. Thus, by alternatively sampling the inlet and exit gases, it was possible to determine relative effectiveness of the catalyst.

Inlet and outlet temperatures and pressures were also measured and recorded. The manufacturer required that the exit temperature never exceed 1800° F. This temperature was closely monitored at each condition to make certain the catalyst was not damaged. The manufacturer felt that for the catalyst to be effective, a minimum inlet temperature on the order of 800° F would be needed. There are a number of operating modes in the

23-mode schedule where this was not possible even with the catalysts close-mounted.

Figure 13 illustrates the installation and sampling arrangement for this step of the project. Additional air for oxidation was provided by the exhaust manifold air injection system normally used for such purposes.

Figure 14 shows the "before" and "after" HC, CO and NO_x for the series of tests made with the oxidation type catalyst. It is difficult to make a direct comparison between the results on Figure 14 and other treatments such as the standard engine with air injection alone, or light duty EGR as were described on Figure 9. This is because fuel and exhaust systems were different, as was the point at which the exhaust was obtained, especially the "before" sample. Incidentally, audible detonation or knock, though intermittent, was experienced on the Indolene Clear at 17 and 25° BTDC when operating at part to WOT throttle position at 1200 and 2300 rpm (above 50 percent power). The knock was not excessive though it was worse at 1200 than at 2300 rpm. An accurate indication of the catalysts effectiveness is, however, portrayed by Figure 14 as to its dramatic reduction of both HC and CO. BSFC, computed on a cycle weighted basis, shows a minimum at 16°BTDC.

Figure 15 is a bar chart representation of the influence of the catalyst on emissions when non-standard carburetor jets and rods (0.075 and 0.028) were employed to richen the mixture. Also, the effect of the catalysts on emissions without air injection is shown. This test, made at standard timing, indicates the need for supplemental air for adequate catalyst operation with this particular engine. In any event, CO reduction was judged poor.

Richening the mixture lowered NO_x, but in doing so, increased CO substantially while having the same effect on HC. It seems that the catalyst is capable of removing a certain amount of CO under the conditions experienced and purposely increasing fuel to air to quench NO formation is not adequately compensated for by the catalyst as tested. Possibly more surface area, i.e., two in series with additional air injection may have helped, though the temperature release can become excessive.

Appendix M contains the tabular and graphed results of the exhaust emissions, etc., for this series of tests. Computer print-outs for the "before" and "after" test series are included. The "after" results, i.e., the emission rates from the engine after passing through the catalyst devices, are plotted against percent power per the 23-mode test.

In summary, it appears that an oxidation catalyst of the type tested has great promise in reducing tailpipe emissions from engine 2-3 on the experimental 23-mode test procedure. Though a sweeping statement regarding the use of catalysts on trucks and their durability cannot be made,

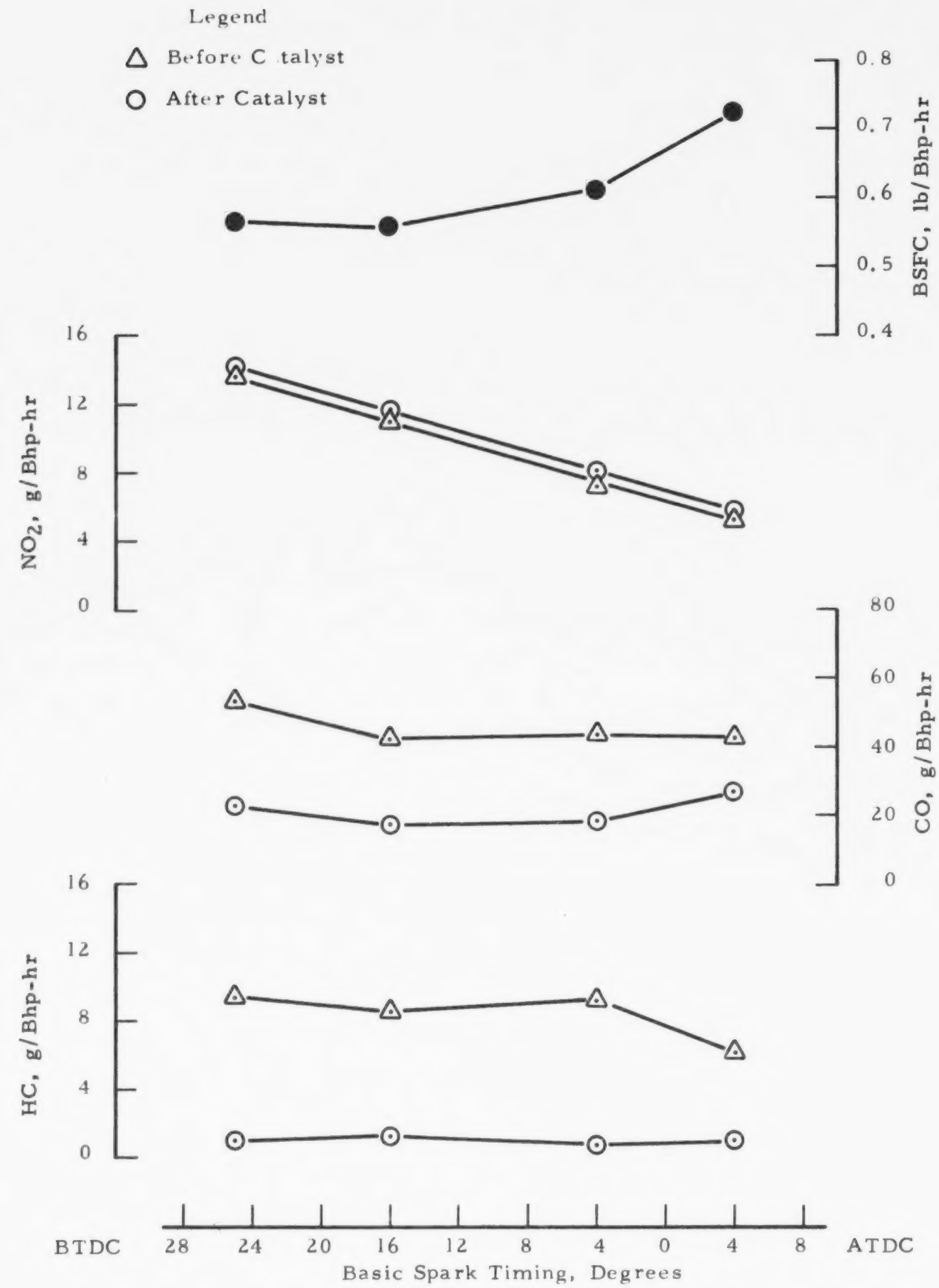


FIGURE 14. EFFECT OF OXIDATION CATALYST ON EMISSIONS ENGINE 2-3, 23 MODE TEST

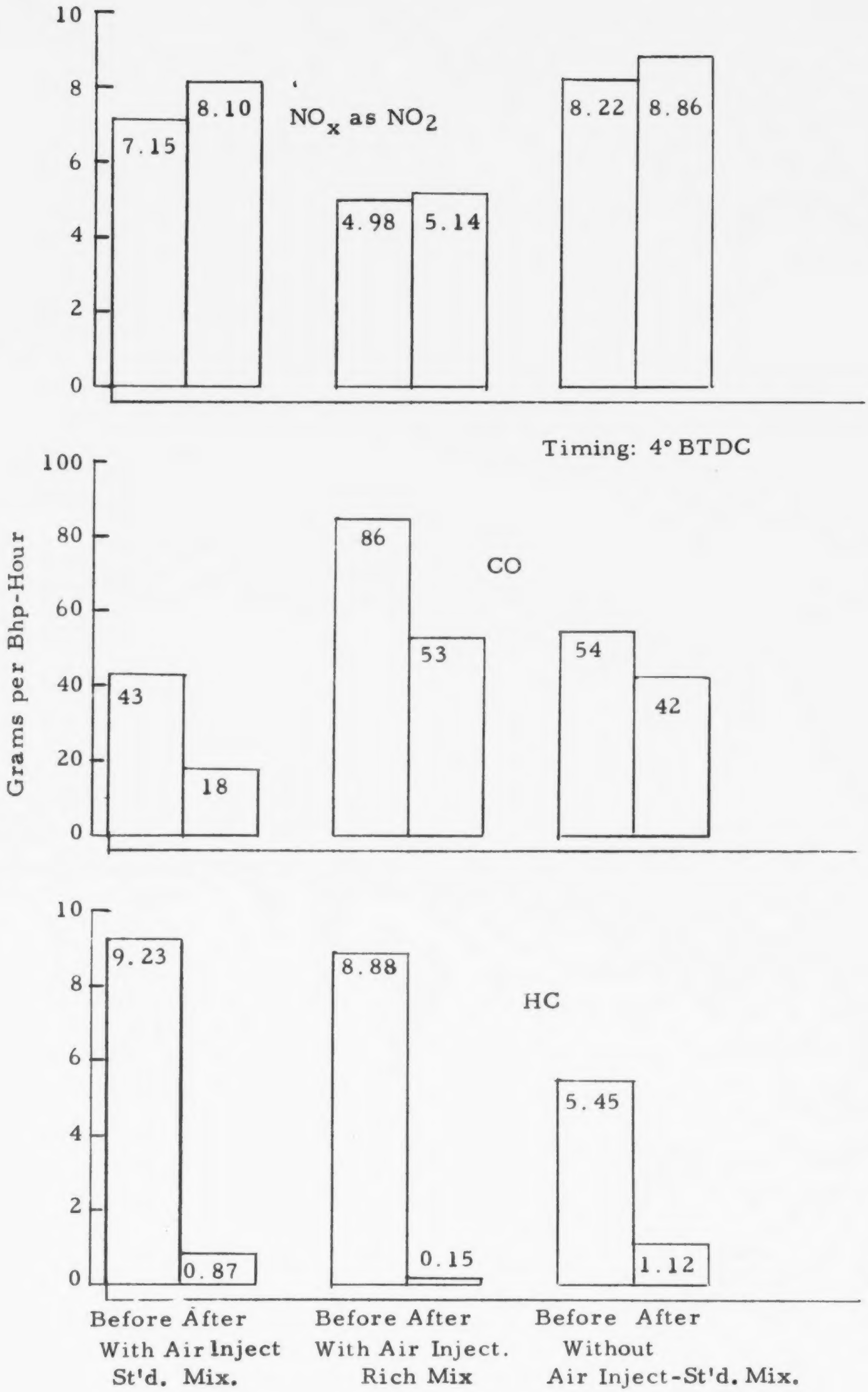


FIGURE 15. EFFECT OF OXIDATION CATALYST ON 1972 STANDARD ENGINE WITHOUT AIR AND WITH FUEL RICH MIXTURE ENGINE 2-3, 23 MODE TEST

the improvements in emission concentrations and mass rates tend to agree with the extensive light-duty experience with this commercially available material. Whether it is sufficiently durable in truck service and whether lead sterile fuel is available are factors that remain to be seen. There were no obvious engine malfunctions or problems due to the catalyst that might affect driveability since no changes are necessarily needed to the carburetor and distributor or the engine to obtain the improvements noted. There are controls that must be applied to prevent the item from being run on fuel containing lead at excessive temperatures (i.e., with excessive CO and HC, etc.), and in isolating the items such as reactor and adjacent piping that experience high temperatures from the vehicle or the environment.

(h) Step 7 - Derating by Carburetor Restriction

This item, of low priority, was considered of interest since the effect of a power reduction on emissions might more than compensate for the power loss that may be associated with some controls. Incidentally, in several steps of this phase, the engine power output was unintentionally derated because of the control device characteristics.

One fairly simple way to intentionally derate the engine was to operate engine 2-3 with only the front two, small, venturis of the four barrel Rochester carburetor. A plate was made that effectively blocked off the rear two venturis, which normally are not in use, and a 23-mode test was run. The engine appeared to run fine at 1200 and at 2300 rpm with little derating of power at 2300 rpm noted. No doubt, that the engine's high speed power was reduced, but at the two speeds used in the 23-mode test schedule, only about 8 percent loss in peak power was found at 2300 rpm. The tests of this item were terminated at this point since time and funds did not permit further testing. Operation on only one barrel was considered, but would require a special mixing section between the carburetor and the intake manifold to improve mixture distribution.

The results of the single run are compared below with a standard engine with unmodified carburetor. Only CO seemed affected to any extent, however, this result has not been verified by sufficient replication.

	grams per bhp-hr 23-mode					
	HC	CO	NO_x	BSFC*	Max. Power, hp *	
Standard Engine Carburetor Standard	7.01	56.2	8.6	0.621	@ 1200	53
					2300	114
Standard Engine Rear Barrels of Carburetor Blocked	7.97	32.4	9.3	0.609	1200	53
					2300	105

*Weighted per 23-mode test.
**Observed flywheel.

For further details on this single test, please refer to Appendix N.

(i) Step 8 - Combination Tests

The test plan called for combination of the best features of experiments in previous steps and then performing emissions tests. A natural adjunct of this step would be optimization of the control combination(s). The limited time and funds prevented this from being done and only the one best overall combination, with slight variation, was tested. The test series involved 23-mode tests, then nine-mode tests, then additional 23-mode tests with aldehyde measurement (extended tests). Then the engine was returned to original condition as closely as possible and a 23-mode, nine-mode series performed.

The combination tested was standard 4° BTDC spark timing, standard carburetor jets, standard, light-duty EGR, oxidation catalyst and manifold air injection. For comparison, the results are shown in Table 12. Samples were obtained before and after the oxidation catalyst. No optimization or calibration was made of the control engine. A 4°ATDC alternative to the standard 4° BTDC was tried. The slight improvements in emissions hardly justified the loss in fuel economy, i.e., higher brake specific fuel consumption.

The second entry on Table 12 summarizes the results of a series of runs made after the engine was returned to its original, standard, 1972 configuration for direct comparison to the tests made on 6-15, 16-72. The standard engine did not change materially during the two months of experimentation. Appendix P contains the run results for the two 23-mode tests made on 8-3-72 with the engine returned to standard configuration.

Using the last, 8-3-72, test made on the standard engine as a basis for reference, the following comparison is offered. Roughly a 70 percent reduction in HC (from 7.31 to 2.13 grams per bhp-hour), a 68 percent reduction in CO (from 51.4 to 16.61 grams per bhp-hour), a 30 percent reduction in NO_2 (from 9.0 to 6.24 grams per bhp-hour), and a 58 percent reduction in aldehydes (from 0.262 to 0.110 grams per bhp-hour) was obtained. This was achieved with only a nominal change in cycle weighted BSFC from 0.622 to 0.668 or a 7.4 percent change (loss) and essentially no change in top end power at 2300 rpm.

More could be done to improve control effectiveness given additional time and funds. A different EGR schedule, tailored to the 23-mode test, would have shown more improvement in NO_x for example or a reduction catalyst may well have made an even greater reduction in NO_x. An advanced technology oxidation catalyst might have done more to reduce CO, HC, and aldehydes as well.

TABLE 12. ENGINE 2-3, 23-MODE EMISSION REDUCTIONS

Configuration	Date	Runs	Grams/bhp-hour, average					Hp. Obs. @
			HC	CO	NO_2	Alde.	BSFC	2300 rpm
Standard 1972	6-15,16-72	2	7.01	56.20	8.60	0.262	0.621	114
Standard 1972	8-3-72	2	7.31	51.40	9.00	N/A	0.622	109
Controlled*	7-28,8-1,2-72						0.668	
Before Cat.		4	13.08	28.99	6.20	N/A		110
After Cat.			2.13	16.61	6.24	0.110		
Controlled**	7-28-72	1				N/A	0.827	97
Before Cat.			8.33	29.08	4.32			
After Cat.			1.67	18.92	4.23			

*1972 Standard Engine with oxidation catalyst and Light Duty Air Injection and EGR system.

**Same as *, but 4° ATDC Basic Timing.

In conclusion, the extent of control is far from optimum and appears to be a minimal level that could be achieved using commercially available devices. Though the engine was never installed in a truck and the resulting driveability assessed, it is unlikely that a serious impairment will result since the light duty EGR schedule was adhered to and timing was unchanged. Only negligible changes in power output and brake specific fuel consumption resulted based on the 23-mode test.

For additional details, modal and individual 23-mode run results, please refer to Appendix O. The tabular data in Appendix O for the four runs made with the best combination on 7-28, 8-1, 2- 1972 show satisfactory test repeatability. The graphed results for the best combination, after catalyst, are shown in Figures 0-1 through 0-3 for HC, CO and NO_x, and are included for further consideration if desired.

Tests were also made using the nine-mode FTP with the results expressed in concentration and grams per bhp-hour. These results are summarized in Tables 13 and 14. The first two entries in both tables, for Standard 1972, show good agreement even though over two months had elapsed between tests of this configuration.

Comparing the Table 13 concentration results with the controlled engine to those with the most recent test series in standard configuration, the emission controlled engine must be termed an improvement with regard to CO and NO, but a penalty regarding HC. This same conclusion may be

TABLE 13. ENGINE 2-3 NINE-MODE 1972 FTP EMISSION REDUCTIONS (Concentration Basis)

Configuration	Date	Runs	Concentrations, Average HC ppm Hex.	CO, %	NO, ppm Corr.
Standard 1972	5-12-72	3	116	0.66	1601
Standard 1972	8-4-72	3	117	0.57	1660
Controlled*	8-2-72	3	129	0.09	641
Current Federal Limit			275	1.5	None
Proposed Federal Limit			160	0.8	2000

*1972 Standard Engine with oxidation catalyst, Light Duty Air Injection, and EGR System.

TABLE 14. ENGINE 2-3 NINE-MODE 1974 FTP EMISSION REDUCTIONS (Mass Basis)

Configuration	Date	Runs	Grams/Bhp-Hour, Average CO	HC	NO_2	HC + NO_2
Standard 1972	5-12-72	3	31.4	3.36	11.20	14.56
Standard 1972	8-4-72	3	22.1	2.87	9.74	12.61
Controlled*	8-2-72	3	4.7	2.86	6.26	9.12
1973 California Limit			40			16
1975 California Limit			25			5

*1972 Standard Engine with oxidation catalyst, Light Duty Air Injection and EGR System.

reached from the data in Table 14. Although the nine-mode CO and NO results seem fairly consistent with the 23-mode, HC definitely was not. Incidentally, the nine-mode overstates the reduction made in CO relative to the 23-mode test while the nine-mode seems to understate the HC improvement relative to the 23 mode. Had the nine-mode FTP been used to evaluate the control technology assessment instead of the 23-mode test, it is unlikely that the same optimization of the final emissions control system would have been used.

It appears that the catalyst and air pump did little if anything to reduce HC even though it is known by the 23-mode test mode-by-mode results that it was doing a job.

To try and understand more about what causes these apparent inconsistencies, a mode-by-mode analysis of nine-mode FTP results in standard and control equipped configuration was made. Table 15 lists the dilution factors and weighting factors for the average standard and the average control equipped run. Also listed are the average CO_2 raw concentrations which have the major influence on the dilution factor. The air pump dilutes the exhaust sufficiently to cause the modal difference shown, and when multiplied by the appropriate FTP weighting factor and summed, the air pump can be seen to change the overall dilution factor from near unity (1. 1) as normal, to 1. 7.

The dilution factor is not, however, the only reason since it affects CO and NO also. It then reverts to the ability of the control system to show the large reductions throughout the nine-mode test, especially those with a large dilution and weighting factor. Data to substantiate this are also listed on Table 15. Note the raw, adjusted (for dilution) and weighted HC values for standard and controlled. For discussion, consider the weighted HC for each engine configuration.

Modes 1, 3, 7, and 8 (Idle, 10-inch, 3-inch, and the last 16-inch Hg intake manifold vacuum) were lower with the controlled engine. Modes 2, 4, and 6, all 16-inch, modes 5 and 9, the 19-inch and closed throttle, were substantially higher in some cases with the controlled engine. The modes in which the controlled engine was better than standard amount to 66. 5 percent of the cycle weight. Even so, the rather poor performance of the controlled engine, i. e., HC worse than standard due to EGR, etc., caused the HC to remain about the same overall.

A history effect may also be noted by looking at the repeated 16-inch condition, modes 2, 4, 6, and 8. Apparently the catalyst and air injection system, which depend heavily on available heat energy in the exhaust stream, were adversely affected by the prior conditions. Only after the 3-inch, near wide open throttle condition was the catalyst effective on hydrocarbons. The 19-inch, mode 5, was quite interesting since apparently the EGR spoiled normal combustion with insufficient heat energy available from the mode or previous mode to effect any clean-up. When using the light duty EGR system, employed in the 23 mode runs, it would be necessary to develop a different rate controller component to preclude operation under those conditions of the nine-mode schedule where EGR had an adverse effect. For further analysis of the data along these and other lines, please refer to Appendix O and P. Appendix O contains nine-mode concentration and mass results with the "best combination" while concentration and mass results by the FTP are included in Appendix P.

TABLE 15. ANALYSIS OF NINE MODE FTP HC RESULTS
ENGINE 2-3

			Standard 1972					Controlled				
					HC, ppm n Hex.					HC, ppm n Hex.		
Mode	Intake Vac, in Hg.	Wt. Fact.	Raw CO_2, %	Dil. Fact.	Raw	Adjusted	Weighted	Raw CO_2, %	Dil. Fact.	Raw	Adjusted	Weighted
1	**Idle**	0.036	13.32	1.032	209	216	7.78	9.09	1.585	23	36	1.30
2	16	0.089	13.35	1.073	81	87	7.74	8.79	1.605	190	305	27.15
3	10	0.257	13.51	1.063	49	52	13.36	10.67	1.350	13	18	4.63
4	16	0.089	13.48	1.065	44	47	4.18	9.00	1.592	56	89	7.92
5	19	0.047	13.52	1.063	30	32	1.50	7.02	1.868	647	1299	56.82
6	16	0.089	13.46	1.067	42	45	4.01	9.03	1.583	72	114	10.15
7	3	0.283	13.90	0.998	78	78	22.07	13.15	1.088	12	13	3.68
8	16	0.089	13.59	1.056	35	37	3.29	9.25	1.640	14	23	2.05
9	Closed Throttle	0.021	8.14	1.354	1935	2620	55.02	4.74	2.873	320	919	19.30
						TOTAL	118.95					133.00

In summary of the nine-mode FTP experiments, the emission results appear quite cycle dependent. The findings here do not necessarily conflict with earlier reported data which showed that the 1973 standard version to give higher emission results than the 1972 standard version by the 23-mode test, yet represented an improvement by the nine-mode FTP. It means that it depends on how one goes about reducing emissions. On one procedure it may help and on another, it may not.

(j) Step 9 - Other Methods

Time and financial limitations constrained this research to the previous items listed. However, several other promising control approaches applicable to the gasoline truck above 6,000 lbs. were seriously considered. Turbocharging was considered seriously enough to request engineering and performance data from the manufacturer, who provided turbochargers appropriate for engines 2-3 and 1-3. Time and funds precluded their inclusion in the test program.

Electronic fuel injection was also investigated with representatives of a leading component company. Such a system, though under active development for use on engines similar to numbers 2-3 and 1-3, was not available for our test. There are programs in progress to bring electronic fuel injection to a reality in the future and this method and its potential for control should not be overlooked. Electronic fuel injection with closed loop control, seems to be the ultimate and its potential emissions benefit could be substantial.

The third major item, and one that was nearly included, was a reduction catalyst for NO_x control. This item was disclosed at the EPA suspension hearings in April of 1972 with dramatic performance on NO_x claimed on the light-duty test. Used in combination with an oxidation catalyst, the strict 1976 light-duty standards were claimed to be met. Repeated attempts to obtain samples for evaluation resulted in an impasse regarding the rights-in-data clause of the manufacturer's Non-Disclosure Agreement. This point could not be resolved in the time remaining under the project and accordingly the item was not evaluated. Had there been at least a month of test time available for engine-catalyst optimization, this issue could have been resolved. The short time frame for testing under this project made this impossible. These three major items should definitely be included in any future control technology assessment project. They all have potential for heavy-duty trucks.

2. Engine 1-3 Control Technology Results

Tests were conducted on this engine following the preliminary plan of test shown on Table 16. This schedule was revised some from that originally provided the Project Officer by letter dated July 18, 1972 in that

TABLE 16. PLAN OF TEST, ENGINE 1-3

Step	Description
1.	Vary basic timing i. e. say 10° advanced,standard and 10° retarded timing.
2.	Install larger and smaller carburetor jets to modify engine air-fuel ratio at standard timing.
3.	Run laboratory EGR system at standard timing at say 5, 10, and 15 percent total intake air flow as EGR.
4.	Operate exhaust manifold air injection system at standard, advanced, and retarded basic spark timing with standard carburetor.
5.	Install oxidation type catalytic reactor, clean fuel system, and run with air pump at standard timing, advanced and/or retarded. Operate on clear fuel (unleaded), run longer modes and sample exhaust before and after catalysts.
6.	Combine best EGR or catalyst - ignition timing found in Steps 2, 3, 4, and 5.

the reduction catalyst alternative was deleted with its non-availability. Discussions with the engine manufacturer were successful in obtaining carburetor jets larger and smaller in size than standard. Also furnished by the engine manufacturer were cylinder heads and associated air pump valve and tubing for exhaust manifold oxidation experiments. The work plan was a simplified, abbreviated, series that was similar in scope to that used for engine 2-3.

Before starting the test program, the engine heads were removed and replaced with the factory-furnished standard light-duty heads normally used to inject air into the exhaust stream as it leaves the combustion chamber. The heads were all new with new valves, springs, etc. The air pump delivery hoses and tubing for connection of the pump to the injection tubes were installed and connected. The vacuum-operated distribution valve, which is intended to prevent possible exhaust backfiring during closed throttle, was also installed and connected as specified by the manufacturer.

The laboratory exhaust gas recirculation system was identical to that used with engine 2-3. One major difference was the way in which the recirculated exhaust was introduced into the engine. As pointed out with engine 2-3, this is very important in order to maintain even mixture distribution, etc. In the short period of time available, it was decided to use a separate plastic distribution block under the carburetor much as the positive crankcase ventilation system uses. To simplify the design, it was decided to use the same type of plastic block as is used for the PCV and locate both between the carburetor and the intake manifold. To facilitate connection of the EGR and PCV hoses, a 3/4 inch thick aluminum block was inserted between the two plastic blocks. The plastic block has a nicely formed passageway communicating from the common inlet to each of the two openings (barrels) and was well suited for even distribution of the EGR to each throat of the intake system.

It was during the reassembly of the carburetor on the taller stack of items that one ear of the bottom flange of the carburetor broke off. It was felt that a replacement carburetor should be obtained from from the manufacturer and after some conversation with the manufacturer's representative, it was decided to use a 1973 carburetor, not a 1972 unit. They are identical except in jet size. The change in jets was so slight, according to the manufacturer, that it would be within the normal carburetor production tolerance.

The pair of oxidation catalysts were installed as with engine 2-3. The inlets were positioned 20 inches from each engine bank's exhaust manifold flange. The dual exhausts were then connected into a single exhaust pipe and stock muffler. The sample probes were positioned as with engine 2-3 with provision for sampling before and after the catalysts. When the catalytic reactors were not to be tested, they were removed and short, straight pipes inserted in their place.

All operation was with leaded emissions test gasoline except when the catalytic reactors were installed necessitating the use of low lead, Indolene clear, fuel. Figures 16 and 17 show various views of the engine prepared for test. Some of the test items and instruments are also shown.

(a) Step 1 - Effect of Basic Spark Timing on Emissions

The following, Table 17, lists the 23-mode results at various basic spark timings:

TABLE 17. EFFECT OF BASIC SPARK TIMING ON EMISSIONS
23-MODE TEST, ENGINE 1-3

			Grams per bhp-hr				Max. Bhp.	
Date	Run	Timing	HC	CO	NO_2 Obs.	Weighted BSFC	1200 rpm	2300 rpm
8-17-72	2	30°BTDC	15.7	61.1	17.9	0.669	56	113
8-17-72	1	15°BTDC	8.7	72.7	13.6	0.679	57	115
8-16-72	2	6° BTDC	9.4	71.3	8.7	0.720	53	110
8-16-72	3	6° BTDC	8.9	72.8	8.7	0.717	53	110
	Average		9.3	72.1	8.7	0.719	53	110
8-18-72	1	TDC*	8.5	110.1	5.5	0.855	46	99
8-17-72	4	5°ATDC*	9.8	167.8	4.6	1.061	42	87
8-17-72	3	10°ATDC*	9.5	187.7	4.6	1.143	35	79

* Engine operational difficulties encountered

The two runs made on 8-16-72 at 6° BTDC represents the standard engine as far as the control technology laboratory studies are concerned. The first tendency is to compare the average with earlier tests on engine 1-3 that were presented under the baseline portion of the results. Such a comparison should be avoided since the heads and carburetor were new and different from those used as baseline. Thus the lower HC and NO_2 and higher CO reported from the modified engine 1-3 than baseline has no basis for comparison.

The data listed in Table 17 are plotted in Figure 18 and illustrate the trade-off between NO_2 and CO with timing. As timing is adjusted later and later, NO_2 decreased almost linearly. CO seemed to take-off upward after operation at the factory standard of 6° BTDC. The question from these curves is, which is most important, CO or NO_2? In one case, a change in timing of 11° from 6° BTDC to 5° ATDC brought NO_2 down to half while the same timing change almost doubled CO by the 23-mode test.

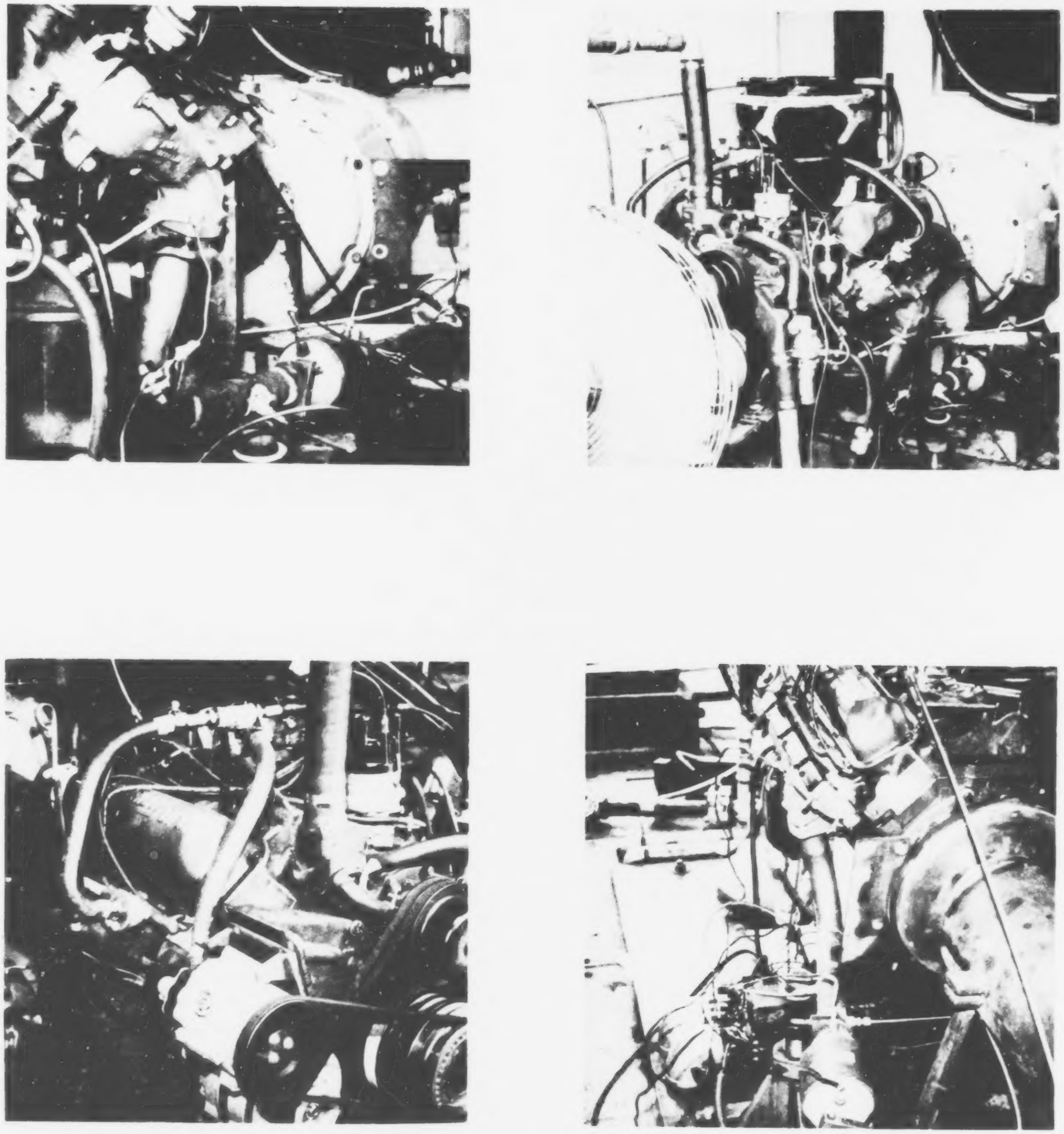
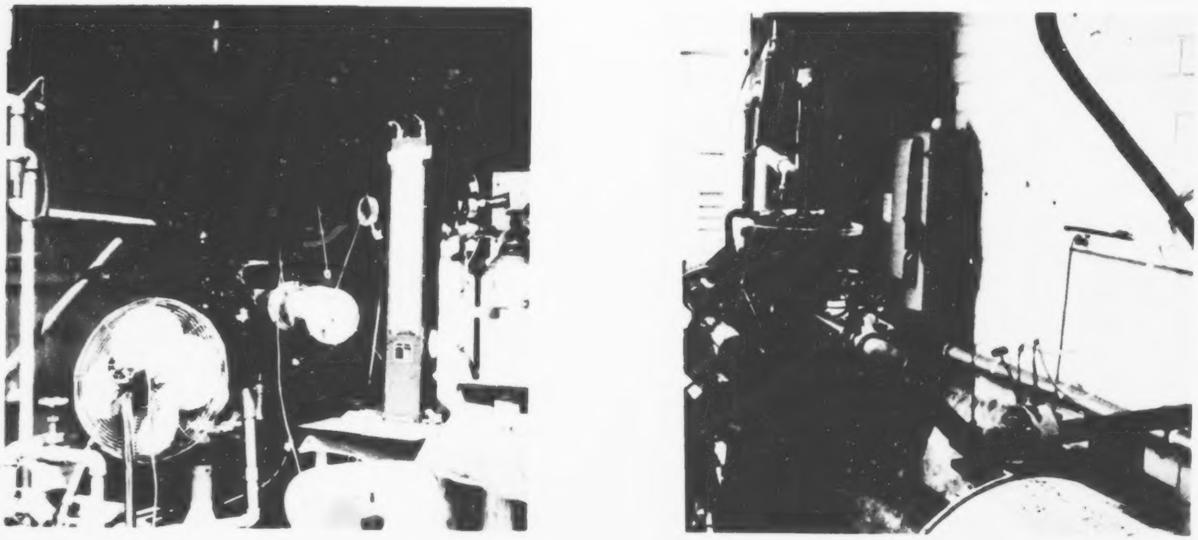
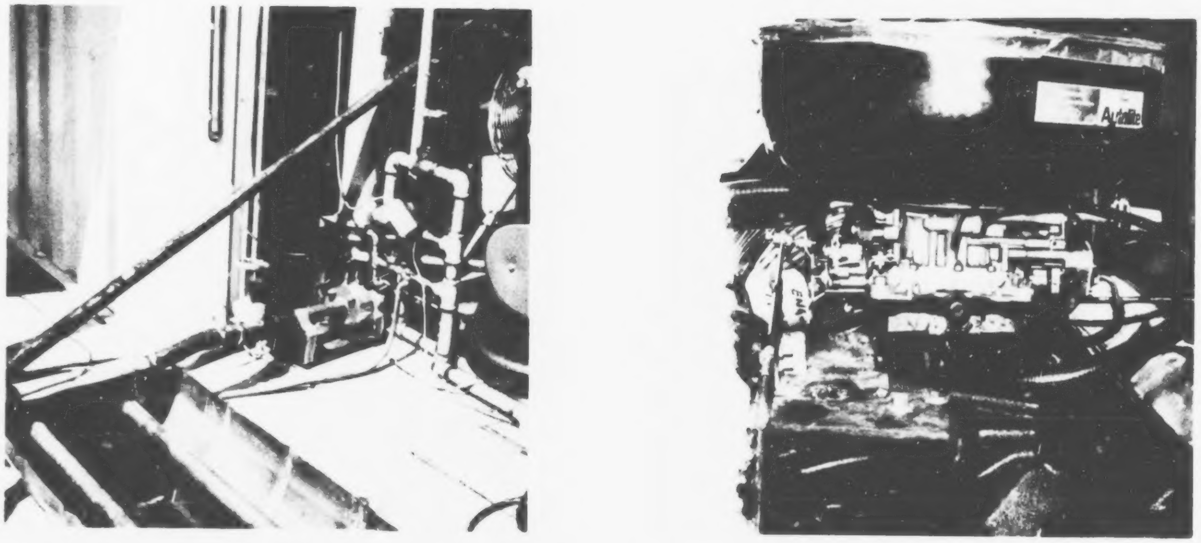


FIGURE 16. VARIOUS VIEWS OF OXIDATION CATALYST AND AIR INJECTION SYSTEM
Engine 1-3



"Cold" EGR



"Hot" EGR

FIGURE 17. LABORATORY SET-UP FOR EGR
Engine 1-3

HC seemed to be little affected by timing. Operational difficulties were encountered at one or more modes at TDC, 5 and 10° ATDC resulting in less than complete 23 mode data. Looking back at Table 17, BSFC was degraded as was top end power at 2300 and 1200 rpm. Cycle weighted BSFC is plotted on Figure 18 for graphical representation. The question from this is: Can the excessive CO be reduced by an oxidation catalyst? Some experiments along these lines will be discussed later.

For more details in terms of computer print-outs and graphs of the results, please refer to Appendix Q. It may be noted from the computer print-outs that several modes were not operable at retarded spark timing. The engine refused to operate at 75 and 82 percent load at 1200 rpm with TDC timing. When the timing was retarded still further from standard, to 5° ATDC and 10° ATDC, the engine would not run at 75, 82 and 92 percent power, 1200 rpm and 75 percent power at 2300 rpm.

(b) Step 2 - Effect of Air-Fuel Ratio on Emissions

To investigate this effect, the main fuel jets were replaced with smaller and larger items and thereby change the air-fuel ratio. As with engine 2-3, the emissions and BSFC behavior of engine 1-3 was plotted against 23-mode cycle weighted air-fuel ratio. The carburetor main jet size in inches is also indicated. The standard size, 0.056 inch, is shown with two richer jets, 0.060 and 0.065 inch, and one leaner jet, 0.051 inch, on Figure 19. A fairly good plot results from this method of presentation. Attempt to operate with larger and smaller jets than those shown were made with unsatisfactory engine operation resulting.

Figure 19 illustrates that the standard engine could be made to produce less NO but again at the expense of a dramatic increase in CO and a small increase in HC. This approach may have some merit in reducing NO_2, if rich enough jets are used. However, something like an oxidation catalyst will have to destroy CO and HC. The remaining point is whether this approach, which increases weighted BSFC from the reference 0.719 to 0.789 for the 0.060 inch jets, as shown in Figure 19, is worth it. Maximum power at 2300 and 1200 rpm seemed little affected by the 0.060 inch jets. An opportunity to compare a larger jet with a catalytic reactor will be given later in this section. For further details and modal data, both on a tabular and a graphical basis, please refer to Appendix R. The engine would not run in mode 6 with 0.051 jets, and in modes 13 and 14 with 0.065 jets.

(c) Step 3 - Effect of Laboratory EGR on Emissions

This step of the project involved using the laboratory system previously described to recirculate a part of the engine's exhaust back into the intake system below the carburetor throttle plate. The system was normally controlled to recirculate exhaust at a fixed percentage of the engine

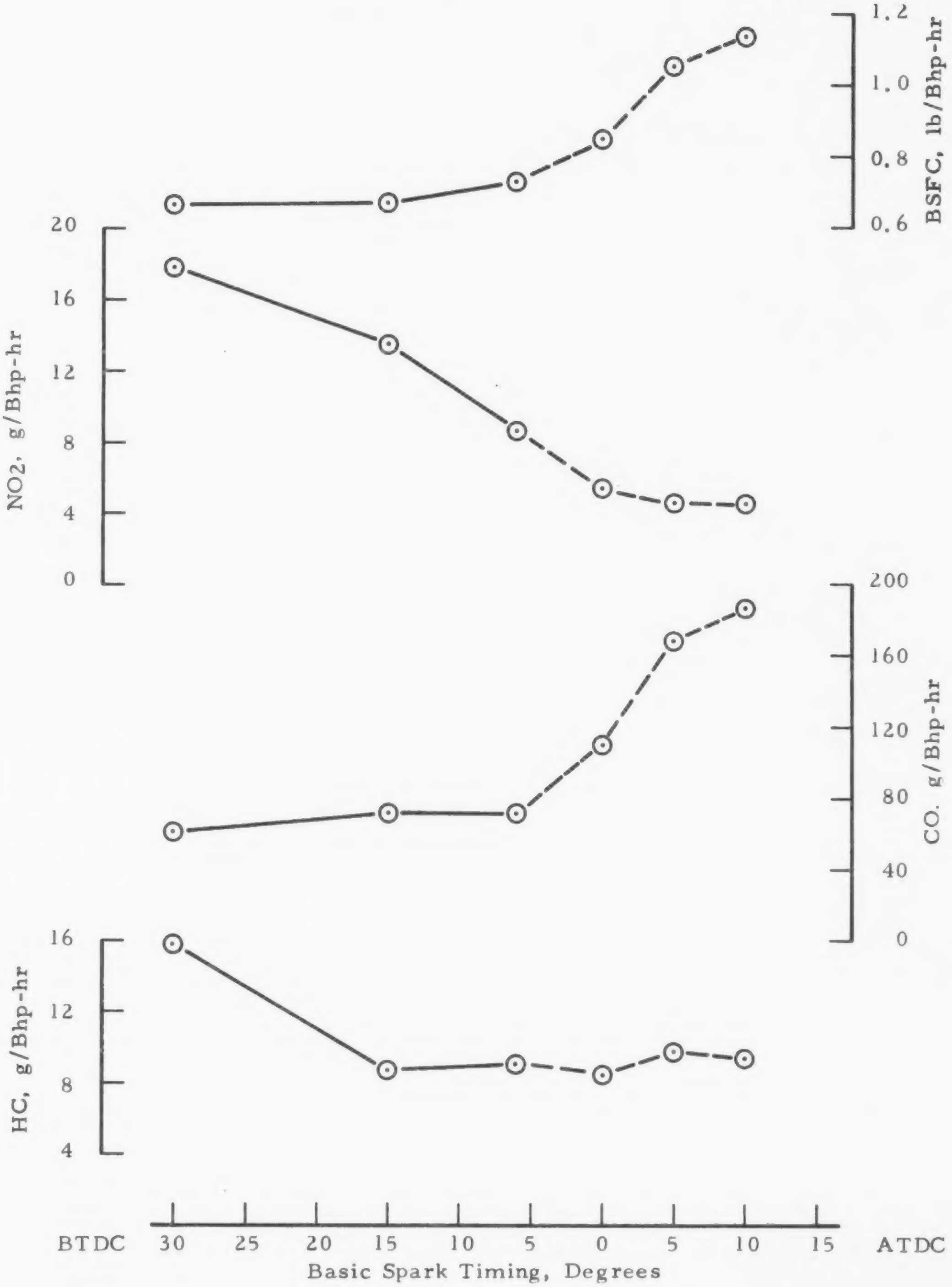


FIGURE 18. EFFECT OF BASIC SPARK TIMING ON EMISSIONS ENGINE 1-3, 23 MODE TEST

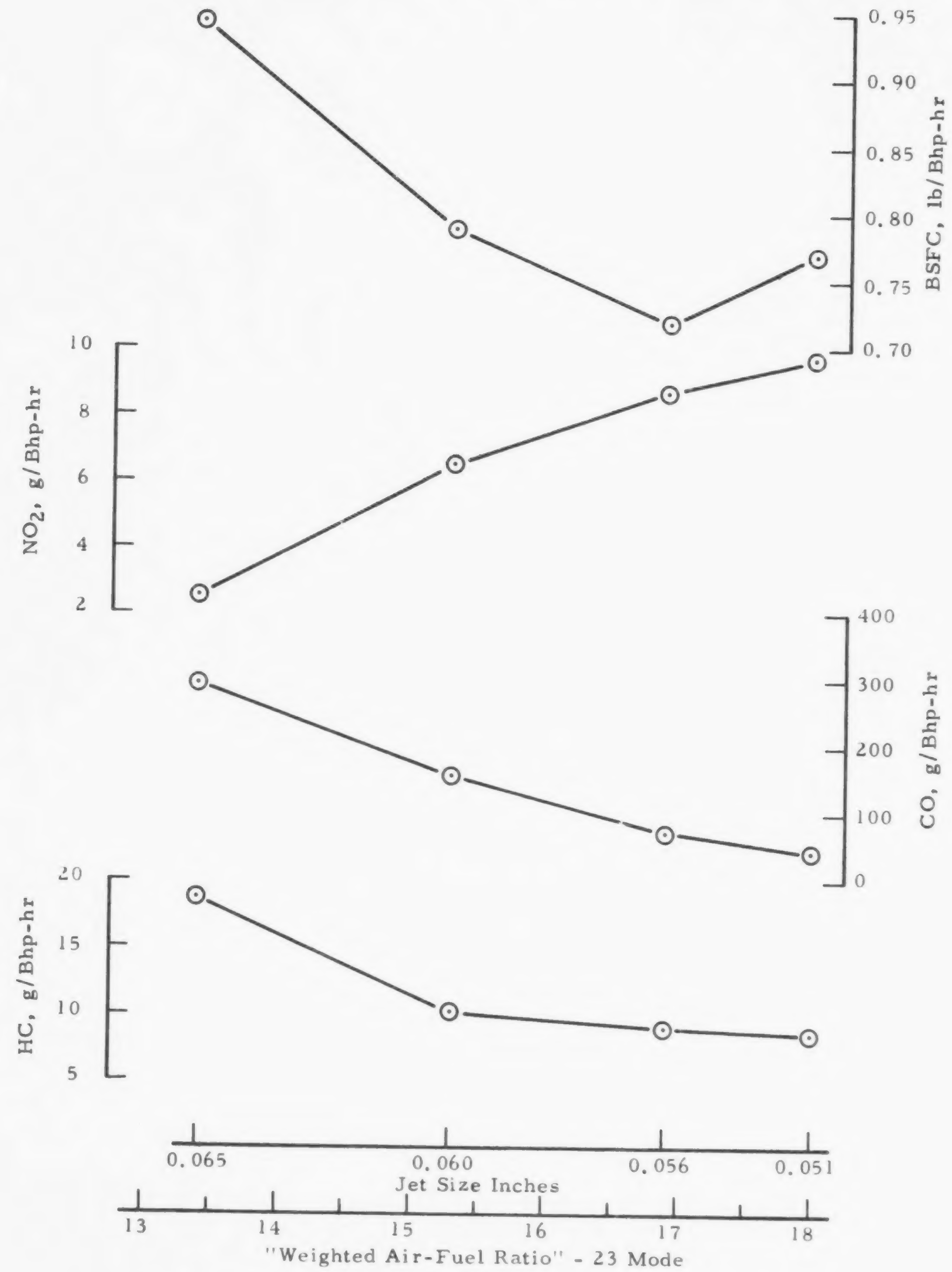


FIGURE 19. EFFECT OF AIR-FUEL RATIO ON EMISSIONS ENGINE 1-3, 23 MODE TEST

inlet flow. The temperature of the recirculated exhaust was generally 100 to 110°F. A strict 23-mode schedule was performed in that the maximum power was first determined using a given fixed EGR rate. Then, the various power points were calculated from the maxiumu per the usual test procedure.

During the running of the 23-mode test, the dynamometer operator was instructed to maintain certain power output and speed and vary throttle setting to do so. The test engineer would adjust EGR rate to obtain the desired fixed percentage EGR by measuring both the carburetor inlet air and exhaust recycle at the same time and performing necessary calculations. It generally required about five minutes to establish the condition properly before exhaust emission measurements could be made.

Figure 20 depicts the HC, CO, and NO_2 emission and cycle weighted BSFC results obtained at 5, 10, and 15 percent EGR. From engine 2-3, it was found that 10 percent EGR was about optimum for NO reduction, yet without seriously jeopardizing engine performance. Accordingly, the EGR rates were selected to bracket 10 percent. Recall that a constant rate of EGR was employed with the exception of closed throttle and idle modes where NO is negligible. Certainly, a constant EGR rate is not optimum for top-end performance or NO_x reduction for that matter. The three constant levels depicted along with zero EGR for reference makes a somewhat complete laboratory study of cooled EGR. The engine was standard otherwise with standard size jets and spark timing.

Cooled EGR has a substantial effect on NO_x formation and results in significant NO_x reductions. Recall that EGR can reduce exhaust volume so that when multiplied by reduced emission concentrations, the result can be substantially lower NO_x. This assumes little or no maximum power output is lost. For additional details, data and graphs covering this series of experiments, please refer to Appendix S. There are many ways the modal data given in Appendix S may be used. One way is to try and derive the best schedule of EGR, tailored to produce minimum NO, without loss in maximum power, with acceptable increases in CO and HC, assuming an oxidation catalyst, and without seriously impairing fuel economy. It is difficult to obtain a large decrease in NO_x by EGR without increase in fuel consumption. The steady increase in weighted BSFC, Figure 20, points up the fuel and inherent operating cost penalty associated with EGR. As a fairly rapid approximation, the EGR schedules shown in Table 18 were selected for test later in the project.

These schedules will be discussed more in a later section where both cooled EGR and hot EGR will be run at 6° and TDC timing. Hot, or unintentionally cooled EGR seems to be the currently accepted method for light-duty vehicles. The use of hot EGR will undoubtedly lower the charge density and thereby degrade top-end performance. The engine will necessarily run as if it is operating on a very hot day. The water of combustion in the recirculated

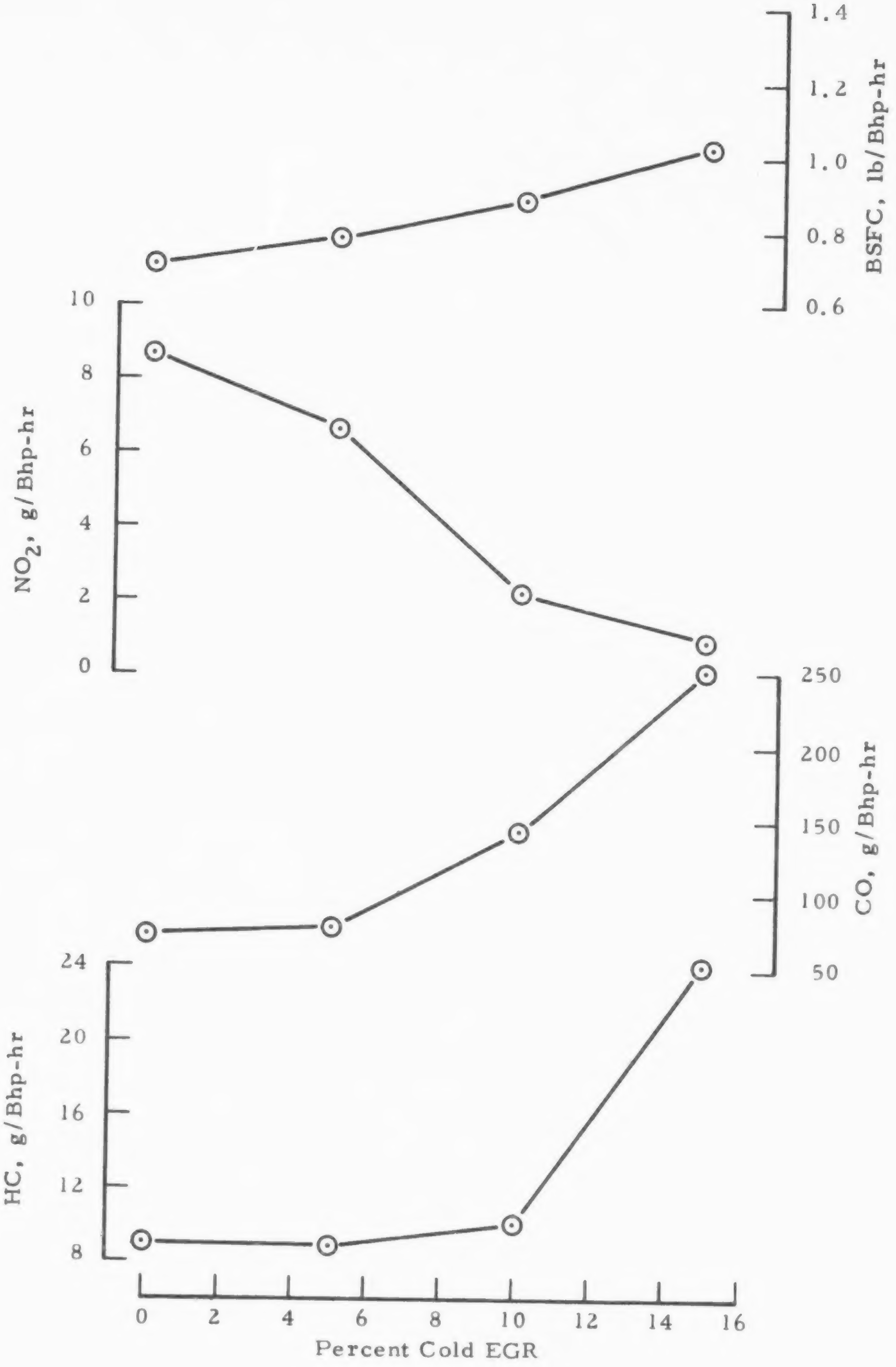


FIGURE 20. EFFECT OF LABORATORY COLD EGR ON EMISSIONS ENGINE 1-3, 23 MODE TEST

exhaust will remain in the recycle and this should help. The EGR will be monitored and adjusted to give a mass percent EGR.

TABLE 18. TAILORED EGR SCHEDULES FOR ENGINE 1-3

			Percent "Hot" EGR		
Mode	Speed	Percent Load	Sch. A	Sch. B	Weight Factor
1	600	0	0	0	0.070
2	1200	2	10	10	0.060
3	1900	8	10	10	0.060
4	1900	18	10	10	0.050
5	1900	25	10	10	0.030
6	1900	50	10	10	0.060
7	1900	75	10	10	0.000
8	1900	82	10	10	0.040
9	1900	92	0	0	0.000
10	1900	100	0	0	0.000
11	600	0	0	0	0.070
12	1200	0(CT)	0	0	0.120
13	2300	100	5	5	0.025
14	2300	92	10	5	0.055
15	2300	85	10	5	0.035
16	2300	75	10	5	0.060
17	2300	50	10	10	0.060
18	2300	25	10	10	0.000
19	2300	18	10	10	0.065
20	2300	8	10	10	0.000
21	2300	2	10	10	0.000
22	600	0	0	0	0.080
23	2300	0(CT)	0	0	0.060

(d) Step 4 - Effect of Factory Air Injection on Emissions

Through the courtesy of the manufacturer, a light-duty air injection system was obtained and utilized in this study. Although air injection by itself had only a slight effect on engine 2-3, it was uncertain what it would do on engine 1-3. In any event, supplemental air or oxygen in the exhaust stream was necessary for oxidation catalyst operation. The light-duty exhaust manifold air injection system is shown in the drawing in Figure 21. It was also shown as installed on the engine in Figure 16 photographs.

The test series involved operation with the complete light-duty system at several basic spark timings namely, TDC, standard (6° BTDC) and 15° BTDC. From Step 1, effect of timing on emission rates, it was shown that this was the range of interest as far as engine operability and emissions performance was concerned. Table 19 lists the 23-mode results when operating with and without the air injection system operative.

TABLE 19. COMPARISON OF EMISSIONS WITH AND WITHOUT LIGHT-DUTY AIR INJECTION SYSTEM
Engine 1-3, 23-Mode Test

Basic Timing	Configuration	Grams per bhp-hr. HC	CO	NO_2	Weighted BSFC
15° BTDC	with air	10.4	45	10.6	0.667
	without air	8.7	72	13.6	0.679
6° BTDC	with air	9.8	60	8.3	0.712
	without air	9.3	72	8.7	0.719
TDC	with air	9.9	64	6.5	0.768
	without air	8.6	110	5.5	0.855

No really gross or consistent improvement on HC and CO may be found by such a comparison when operating with the air system. In all, air injection as a control item on this engine, subjected to the 23-mode test, lacks justification from an emissions reduction standpoint. It will be necessary, however, to utilize an air pump or something similar to provide supplementary oxygen for the oxidation catalyst. For further details, modal results both tabular and graphical, please refer to Appendix T to this report.

(e) Step 5 - Effect of Oxidation Catalyst on Emissions

Before beginning the experiments with the two precious metal catalytic reactors, the manufacturer of the engine and the catalyst were contacted to make certain the light duty air injection system would deliver the proper amount of air for optimum catalyst performance. In discussions with a representative of the engine manufacturer, it was learned that the vacuum-operated valve, item 2 in View A of Figure 21, could be replaced with a simple "tee" fitting. The vacuum-operated valve acts somewhat as a wastegate so that under some engine vacuum conditions, more or less of the air is wasted and not injected.

There are a number of reasons for this valve in the light-duty system and there may be justification for its use in heavy duty. But, it was decided to eliminate the valve with the concurrence of the manufacturer. Trial runs revealed operation to be satisfactory with no backfiring during the closed throttle conditions, etc. Sufficient O_2 in the exhaust was achieved

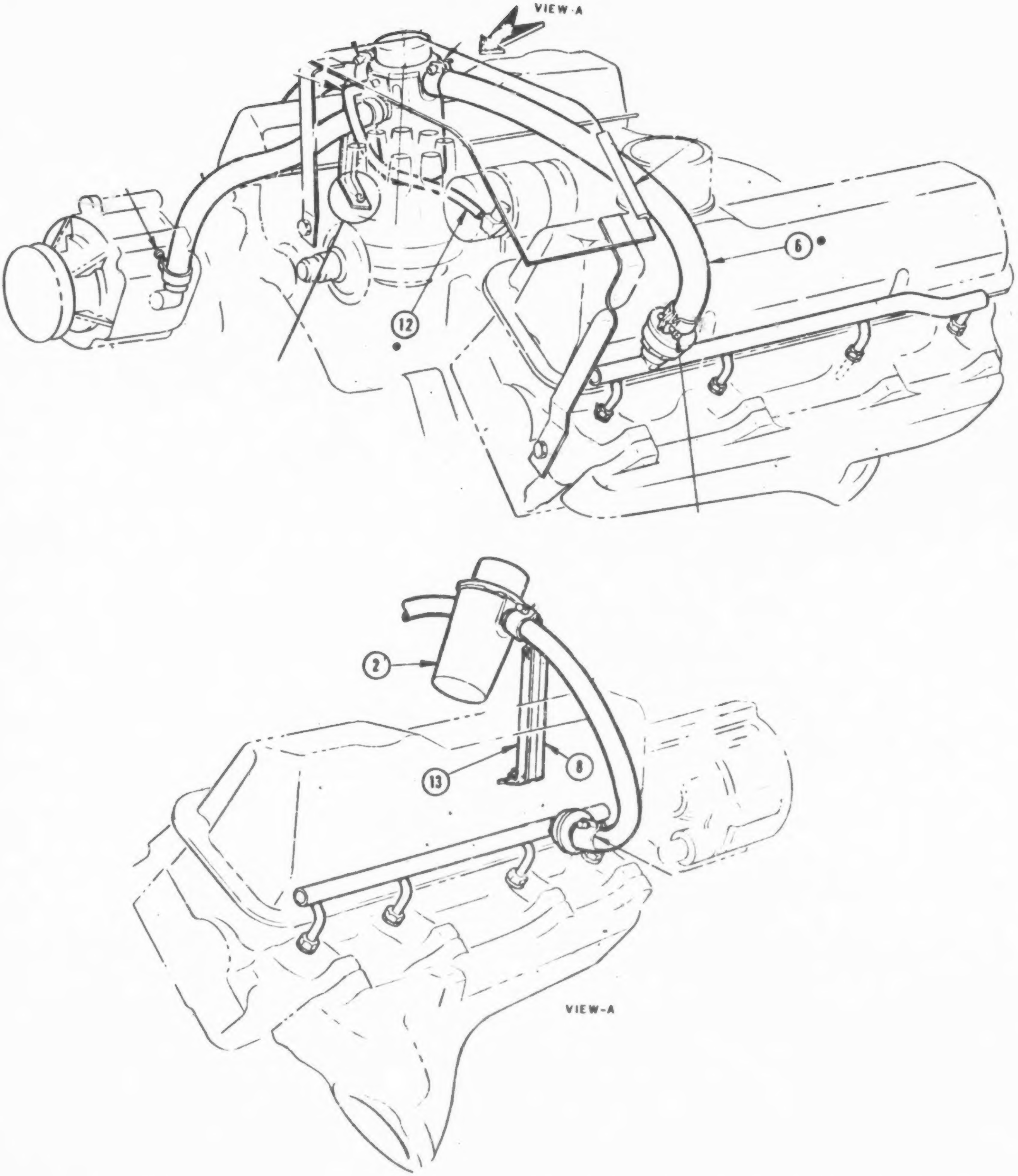

VIEW-A
6
12
2
13
8
VIEW-A

FIGURE 21. LIGHT DUTY EXHAUST MANIFOLD AIR INJECTION SYSTEM

to promote satisfactory catalysis. Please refer to Figure 16 which shows a one-half inch pipe tee used in place of the vacuum valve. The air from the pump is accordingly simply distributed to each bank of the engine.

Figure 22 is a graph of the exhaust emissions measured before and after the catalyst. As with engine 2-3, the catalysts have little effect on NO_x, as expected, an important effect on CO, and a substantial effect on HC. The catalyst must be judged an important item of emissions control and performs a very vital role in lowering CO and HC while not affecting NO_x. It did not seem to matter where the timing was set, although the TDC CO point does not agree in trend with earlier curve of CO versus timing namely, Figure 18. Exactly why CO behavior is erratic at TDC is unknown, but it is apparently not a good engine operating point as mentioned earlier.

The run results made with catalyst treatment are listed on Table 20 and are those plotted on Figure 22. Of interest was the duplicate runs made at 6° BTDC (standard timing) with the light duty air injection system including vacuum-operated distribution valve listed on Table 20. Higher CO and HC by the 23-mode test, were found when the vacuum valve was used. The data points on Figure 22 were obtained with the simple pipe Tee substituted for the waste gate. Weighted BSFC, plotted on Figure 22, shows the familar increase with retarded timing.

The run results seem to indicate that better emissions control can be achieved with catalyst when the full delivery of the air pump is utilized. It may be thought that the effect is one of more exhaust dilution. But, this is not the case when the calculations are based on the carbon balance method as are the 23-mode and Federal nine-mode mass methods.

From Figure 22, it can be seen that most any timing within the TDC to 15° BTDC range may be selected for about equivalent emission improvement. This is the important conclusion to be drawn from the fairly brief series of tests. The "before" and "after" catalyst data are published in tabular form, as computer print-outs, in Appendix U. The "after" modal grams per hour data are graphed against power level and included in Appendix U for further study.

(f) Step 6 - Effect of Various Combinations on Emissions

A few combinations were experimented with to determine how well various control approaches might work overall. Because of interactions, it is not possible to simply add the benefits of control devices. One combination tried under this step, shown in summary on Table 21, was to look quickly at richer jets, 0.063 inch, the modified light-duty air injection with oxidation catalysts but no EGR. Two basic timing settings of 6° BTDC (standard) and an advanced, 15° BTDC were tried. Although the bigger jets at standard timing with the catalyst gives some reduction in NO_2, the CO is unacceptably

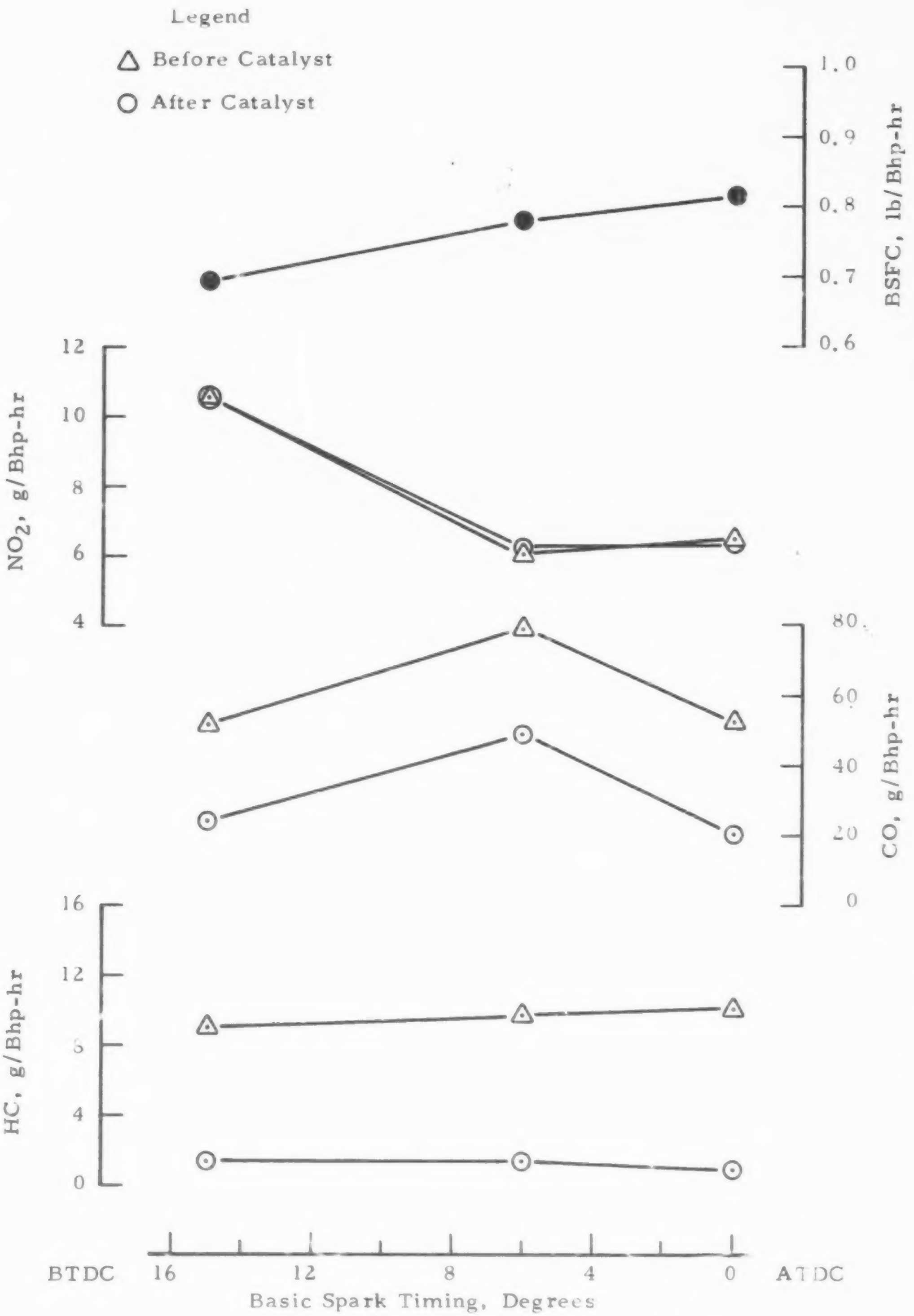


FIGURE 22. EFFECT OF OXIDATION CATALYST ON EMISSIONS WITH SLIGHTLY MODIFIED AIR INJECTION SYSTEM ENGINE 1-3, 23 MODE TEST

TABLE 20. EFFECT OF OXIDATION CATALYST ON EMISSIONS
Engine 1-3, 23-Mode Test

Date	Run	Spark Timing	Sample Point	Grams per bhp-hr			Weighted BSFC
				HC	CO	NO_2	
Light Duty Air Injection System Intact							
8-24-72	2	6°	Before Cat.	10.37	98.7	7.48	0.745
8-25-72	1	BTDC	Before Cat	10.48	96.8	6.32	0.752
	AVERAGE			10.42	97.6	6.90	0.749
8-24-72	2	6°	After Cat.	2.29	61.1	6.78	
8-25-72	1	BTDC	After Cat.	3.13	59.9	6.63	
	AVERAGE			2.71	60.5	6.70	
Vacuum Operated Air Injection Distribution Valve Replaced by Simple Pipe "Tee"							
8-25-72	3	TDC	Before Cat.	10.08	52.6	6.43	0.818
			After Cat.	0.98	21.2	6.37	
8-25-72	2	6°	Before Cat.	9.72	79.7	6.14	0.782
		BTDC	After Cat.	1.43	49.6	6.22	
8-28-72	1	15°	Before Cat.	9.19	52.1	10.61	0.695
		BTDC	After Cat.	1.44	24.2	10.59	

TABLE 21. EFFECT OF VARIOUS CONTROL COMBINATIONS ON EMISSIONS
Engine 1-3, 23-Mode Test

Date	Run	Spark Timing	Catalyst	Grams per Bhp-Hr			Weighted
				HC	CO	NO_2	BSFC
0.063 inch (rich) Jets, Modified LD Air Injection, Oxidation Catalyst No EGR							
8/31/72	1	15° BTDC	Before	8.68	140.8	4.60	0.759
			After	1.70	83.5	5.27	0.759
8/31/72	2	6° BTDC	Before	10.91	211.3	2.97	0.853
			After	2.14	156.6	3.28	0.853
0.056 inch (St'd) Jets, Modified LD Air Injection, Oxidation Catalyst Cold EGR Per Schedule A Rate							
8/28/72	2	6° BTDC	Before	11.73	105.3	2.50	0.855
			After	1.13	63.8	2.41	0.855
0.056 inch (St'd) Jets, Modified LD Air Injection, Oxidation Catalyst Hot EGR Per Schedule A Rate							
8/30/72	1	TDC	Before	13.49	174.2	1.60	0.993
			After	2.11	134.3	1.63	0.993
8/29/72	1	6° BTDC	Before	12.72	149.4	2.51	0.862
			After	1.87	112.2	2.51	0.862
8/30/72	2	15° BTDC	Before	11.51	116.5	2.84	0.766
			After	2.23	73.3	2.54	0.766
0.056 inch (St'd) Jets, Oxidation Catalyst, Hot EGR Per Schedule A Rate, But No Air							
8/31/72	3	6° BTDC	Before	10.40	205.4	2.18	0.852
			After	5.48	169.8	2.09	0.852

TABLE 21. EFFECT OF VARIOUS CONTROL COMBINATIONS ON EMISSIONS
Engine 1-3, 23-Mode Test

Date	Run	Spark Timing	Catalyst	Grams per Bhp-Hr			Weighted BSFC
				HC	CO	NO_2	
0.063 inch (rich) Jets, Modified LD Air Injection, Oxidation Catalyst No EGR							
8/31/72	1	15° BTDC	Before	8.68	140.8	4.60	0.759
			After	1.70	83.5	5.27	0.759
8/31/72	2	6° BTDC	Before	10.91	211.3	2.97	0.853
			After	2.14	156.6	3.28	0.853
0.056 inch (St'd) Jets, Modified LD Air Injection, Oxidation Catalyst Cold EGR Per Schedule A Rate							
8/28/72	2	6° BTDC	Before	11.73	105.3	2.50	0.855
			After	1.13	63.8	2.41	0.855
0.056 inch (St'd) Jets, Modified LD Air Injection, Oxidation Catalyst Hot EGR Per Schedule A Rate							
8/30/72	1	TDC	Before	13.49	174.2	1.60	0.993
			After	2.11	134.3	1.63	0.993
8/29/72	1	6° BTDC	Before	12.72	149.4	2.51	0.862
			After	1.87	112.2	2.51	0.862
8/30/72	2	15° BTDC	Before	11.51	116.5	2.84	0.766
			After	2.23	73.3	2.54	0.766
0.056 inch (St'd) Jets, Oxidation Catalyst, Hot EGR Per Schedule A Rate, But No Air							
8/31/72	3	6° BTDC	Before	10.40	205.4	2.18	0.852
			After	5.48	169.8	2.09	0.852

high, about double the standard or unmodified engine, and the BSFC is also increased.

The results of another combination tried is also shown on Table ~~4~~ 21 for the system. Here the engine was operated with standard 0.056 inch jets, the modified light-duty air injection system and with EGR on a cold and hot basis. The EGR schedule used was Schedule A from Table 18. Schedule A was designed to give the maximum rate of EGR and the maximum NO_2 reduction without serious engine problems. The exhaust was first recirculated through the heat exchanger with the very low NO_2 values resulting per the 8-28-72 runs. CO was not particularly better than unmodified and this caused great concern over this approach. The catalyst was apparently unable to overcome the increased CO by the Schedule A EGR rate.

To study the Schedule A under the more conventional approach of recirculating the exhaust with little or no cooling, i.e. internal EGR as with light-duty gasoline engines, the piping was close connected between the engine's exhaust and the reentry plate located below the carburetor. It may be helpful to look back at the Figure 17 photographs that show only a control valve and thin plate orifice with thermocouple for gas temperature measurement in a relatively short length of pipe. To manually operate the valve, the mass flow of the EGR was instantly computed and compared to the mass flow of air into the engine. The rate was then adjusted as closely as possible to that given for Schedule A in Table 18 and determined on a mass basis.

The results are summarized on the bottom half of Table 21 and are for the engine with standard jets, modified air injection, oxidation catalyst and hot EGR according to rate Schedule A. Three spark timings were run to determine this effect. Basically the same effect on emissions with this combination was found as with cold EGR, namely very low NO_x, high CO and low HC.

Figure 23 shows the before and after catalyst 23-mode results for hot EGR (Schedule A) versus the three timing settings studied, TDC, 6° BTDC (standard) and 15° BTDC. Although 15° BTDC timing looks best, it was decided that this combination had to be improved upon because essentially no reduction in CO was obtained. As with Figure 22, the cycle weighted BSFC increased as basic spark timing was retarded.

Before stopping this series of tests, a run was made to simulate operation with the air pump inoperative as with a broken belt. The results of this run are listed on the bottom of Table 21 and may be compared to Run 1 on 8-29-72 when the air pump was operative. Note the great need for air to oxidize the HC and CO in this test configuration. For more data of a detailed nature, please refer to Appendix V for all the tests summarized

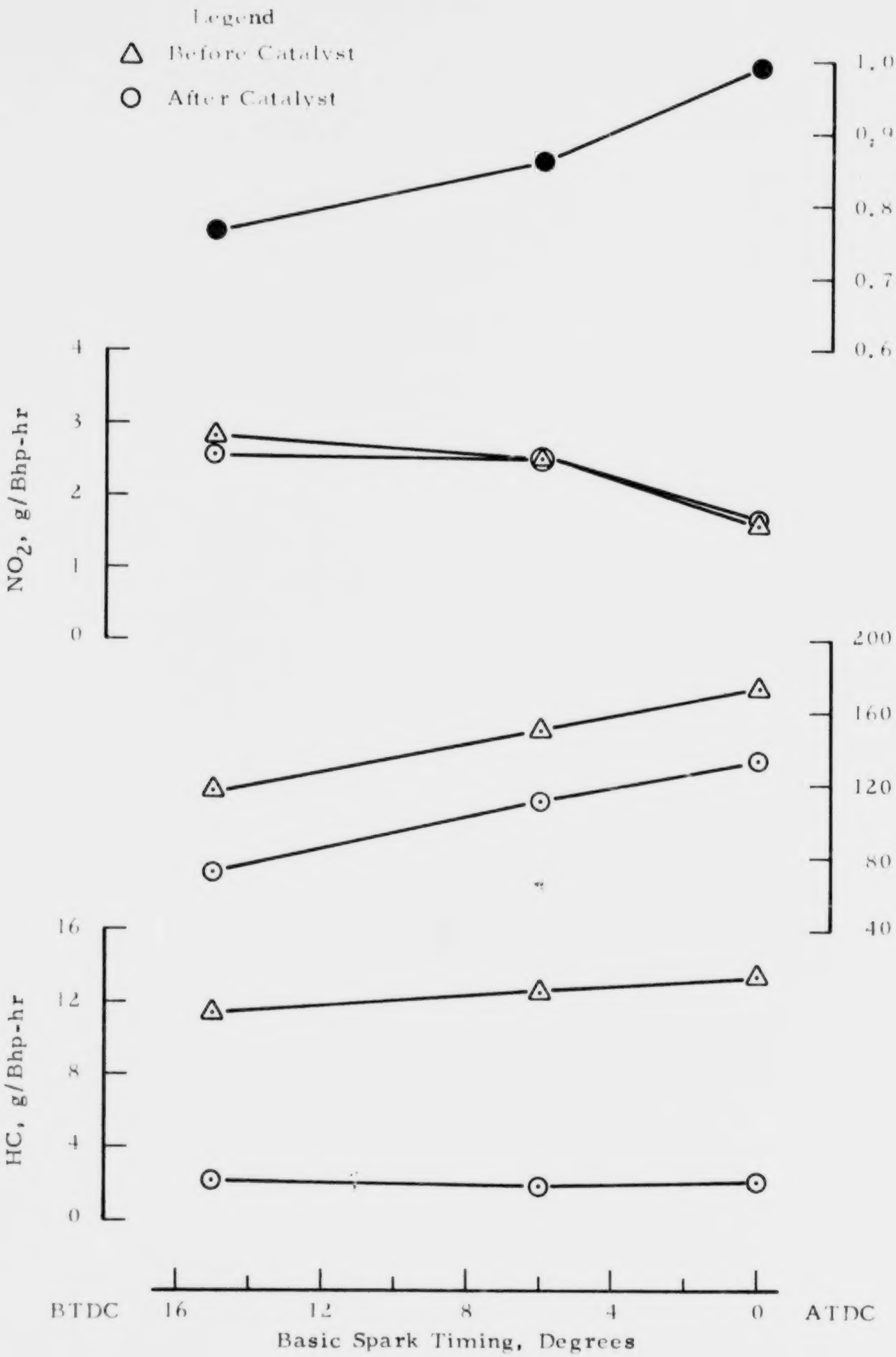


FIGURE 23. EFFECT OF COMBINATION OF HOT EGR (SCH A), OXIDATION CATALYST, MODIFIED AIR INJECTION ON EMISSIONS ENGINE 1-3, 23 MODE TEST

on Table 21. The series of tests with hot EGR versus timing made on 8-29-72 and 8-30-72, are graphed in Appendix V also.

(g) Step 6a - Effect of Best Combination on Emissions

Clearly, a better overall reduction was needed than was found with hot EGR rate Schedule A. Engine 1-3 is extremely sensitive to CO because of a number of factors, one of which is the carburetor action on approaching and operating at wide open throttle. In trying to develop the best compromise, the maximum or top end power should be preserved as much as possible. In this engine, operation at less than two inches Hg intake manifold depression was disasterous on CO in standard or modified condition. Accordingly, Schedule B tailored the EGR to get out of the high CO modes as quickly as possible and, if need be, take the NO_x penalty.

Using Schedule B, also listed on Table 18, fairly good reductions in all emissions were effected and they are shown on Table 22. First, the catalyst did a good job in lowering HC and CO for the best combination as shown by the average before and after results for the three runs made on 9-5 and 9-6, 1972. The resulting HC, CO, NO_2 and aldehydes may be directly compared to the standard, unmodified engine runs made on September 7 and 8, 1972 shown next.

HC was reduced from 8.52 to 1.31 grams per bhp-hr or 85 percent. CO was reduced from 65.9 to 19.2 grams per bhp-hr or 71 percent. NO_x was reduced from 8.34 to 4.09 grams of NO_2 per bhp-hr or 51 percent. Aliphatic aldehydes were also reduced from 0.278 to 0.131 grams of formaldehyde per bhp-hr for a 53 percent change. Cycle weighted brake specific fuel consumption was increased from 0.738 to 0.831 lbs fuel per bhp-hr or 13 percent increase in fuel consumption. In doing so, the "best combination" control strategy reduced top-end power at 2300 rpm from 108 to 95 hp or 12 percent with no effect on power at 1200 rpm.

The data listed on Table 22 is a summary of the individual run results included in Appendix W. In addition to the before and after catalyst "best combination" tabular results, a series of graphs are included that show the average HC, CO, NO_2 intake vacuum, and fuel rate versus power level for 1200 and 2300 rpm. For clarity only, the "best combination" and standard engine results are graphed. The standard engine results are included in Appendix X.

Listed at the bottom on Table 22 are the results of the runs made on August 16, 1972 with the engine in the standard condition prior to the series of tests with control devices, etc. Note the fairly good agreement between the HC, CO, NO_2, power and BSFC between the beginning and ending tests. This indicates the engine did not change or deteriorate materially during the test period. Recall that engine 1-3 used for control technology was modified from that used for baseline testing in that [illegible]

TABLE 22. EFFECT OF "BEST COMBINATION" ON EMISSIONS

Engine 1-3, 23-Mode Test

			Grams Per bhp-hour				Weighted	Max. Hp Obs. at	
Date	Run	Catalyst	HC	CO	NO_2	Alde.	BSFC	1200	2300
0.056 inch Jets (Standard), Modified Light-Duty Air Injection, Standard Timing (6° BTDC), Hot EGR Per Schedule B									
9-5-72	1	Before	11.77	56.9	3.94	---	0.846	50	95
9-6-72	1	Before	11.08	49.1	3.60	---	0.833	52	95
9-6-72	2	Before	10.89	44.2	4.40	---	0.813	52	95
AVERAGE			11.25	50.1	3.98		0.831	51	95
9-5-72	1	After	1.19	23.1	4.03	0.130	0.846	50	95
9-6-72	1	After	1.34	18.4	3.70	0.135	0.833	52	95
9-6-72	2	After	1.41	16.1	4.53	0.129	0.813	52	95
AVERAGE			1.31	19.2	4.09	0.131	0.831	51	95
Standard Engine with 0.056 Jets and 6° BTDC Timing									
9-7-72	1	None	8.14	70.9	8.27	0.285	0.740	52	108
9-7-72	2	None	9.01	67.2	8.32	0.283	0.736	52	108
9-8-72	3	None	8.41	59.6	8.43	0.265	0.738	52	108
AVERAGE			8.52	65.9	8.34	0.278	0.738	52	108
Previously Run Standard Engine with 0.056 Jets and 6° BTDC Timing									
8-16-72	2	None	9.4	71.3	8.7	---	0.720	53	110
8-16-72	3	None	8.9	72.8	8.7	---	0.717	53	110
AVERAGE			9.3	72.1	8.7		0.719	53	110

injection cylinder heads and other changes were incorporated.

It was also important to assess the "best combination" control system by the Federal nine-mode test procedure. This was done in a series of tests and expressed in concentration and mass terms on Table 23.

Some fairly respectable reductions in HC, CO and NO concentrations were achieved by the "best combination" relative to the standard engine. HC was reduced from 109.7 ppm to 54.4 ppm n hexane or 50 percent. CO was reduced from 0.44 to 0.06 percent for a 86 percent reduction. NO, corrected, was reduced from 1597 to 624 for a 61 percent improvement. All this was achieved with the standard engine with modified light-duty air injection, an oxidation catalyst, and tailored hot EGR. These levels may be directly compared to the current and proposed Federal limits listed on Table 23.

Only during the higher power modes, the 3 inch and 10 inch intake vacuum levels, was any EGR allowed. The manual control system recirculated 5 percent during the 3 inch conditions and 10 percent of the airflow (mass basis) during the 10 inch mode. All other times, idle, closed throttle, 19 inch and 16 inch, the EGR valve was shut-off.

Table 24 shows a summary of the "best combination" control engine relative to the unmodified engine in terms of grams per bhp-hour using the 1974 Federal Test Procedure calculational method. Note that HC was reduced 48 percent from an average of 3.99 to 2.07 grams per bhp-hour. CO was reduced 85 percent from 24.1 to 3.6 grams per bhp-hour. NO_2 was also reduced by 54 percent from 12.92 to 5.92. $HC+NO_2$ was 7.99 with the controlled engine relative to 16.91 grams per bhp-hour with the standard engine. These levels may be compared with the 1973 California and 1974 Federal standards of 40 grams of CO and 16 grams of $HC+NO_2$ per bhp-hour. Appendix W contains the nine-mode concentration and mass emission results for the engines equipped with the "best combination" of control technology. The results for the two runs made in standard configuration are included as Appendix X. It is interesting to observe the dissimilarity in nine-mode results of engine 1-3 and 2-3. Recall engine 2-3, run with the "best combination" of light-duty air injection, light-duty EGR, oxidation catalyst and standard otherwise was not as effective on the nine-mode test as it was on the 23 mode test. The light-duty EGR valve and its schedule resulted in sufficiently higher HC that could not be reduced by the oxidation catalyst. With engine 1-3, the manual control, laboratory EGR system was not used in those modes of the nine-mode procedure where the reductions in NO_x were outweighed by increases in HC and CO.

Of course, the laboratory EGR with manual control tailored for optimum improvement is nothing more than a laboratory approach, a gadget

TABLE 23. ENGINE 1-3 NINE MODE FTP EMISSION REDUCTIONS (CONCENTRATION BASIS)

Configuration	Date	Runs	Concentrations, Average HC ppm Hex	CO %	NO, ppm Corr
"Best-Combination"	9-1-72 9-5-72	3	54.5	0.06	624
Standard	9-8-72	2	109.7	0.44	1597
Current Federal Limit			275	1.5	none
Proposed Federal Limit			160	0.8	2000

TABLE 24. ENGINE 1-3 NINE MODE FTP EMISSION REDUCTIONS (BRAKE SPECIFIC BASIS)

Configuration	Date	Runs	Grams per bhp-hour, average CO	HC	NO_2	HC + NO_2
"Best Combination"	9-1-72 9-5-72	3	3.6	2.07	5.92	7.99
Standard	9-8-72	2	24.1	3.99	12.92	16.91
1973 California and 1974 Federal Limit			40			16
1975 California Limit			25			5

or means to an end. It demonstrated control possibilities but is, of course, not a proven scheme. No really good idea was obtained about driveability, although the final system could run smoothly in all steady state modes regardless of test schedule. Durability along with driveability for the entire system remains to be demonstrated and, of course, its applicability to engines in general. In defense of the control system, it employed proven oxidation catalysts, light-duty air injection and a fairly simple to automate EGR schedule. No drastic power derating or increase in fuel consumption resulted. The final strategy for both engines 1-3 and 2-3 were almost similar in final design. The only significant difference was in the EGR rate schedule employed. The tailored schedule employed with engine 1-3 was found superior overall for both 23 and nine-mode tests to the light-duty EGR system rates.

Much the same comment regarding advanced or additional control items for study with engine 1-3 can be made as with engine 2-3. The advanced oxidation and oxidation-reduction catalysts, turbochargers, automated EGR valves, fuel injection, etc. were clearly beyond the scope of this project but are not beyond the realm of possibility for effecting even greater reductions than found in this initial project. Such items may effect the same level of control without driveability, fuel and power penalties associated with the currently discussed "best combination". The words "best combination" have always been with quotes because with the fast moving field of emissions technology, this is expected to be short-lived. Another such study is bound to result in a further advance in knowledge and far surpass the performance of the work done so far.

V. SUMMARY AND CONCLUSIONS

The following key points summarize the important findings during this project. Where appropriate, conclusions are presented.

(1) Six 1972 spark-ignited gasoline-fueled engines, three each from two manufacturers, were subjected to a series of baseline exhaust emission tests. The engines included small six cylinder and large V-8 displacement sizes representative of engines popularly used in vehicles rated over 6,000-lb gross vehicle weight. The nine-mode Federal test method, in terms of concentration of hydrocarbons, carbon monoxide, and nitric oxide was performed. The emission results were then converted to mass units of grams of contaminant per bhp-hour using the California ARB procedure for 1973. The latter procedure requires the accurate measurement of flywheel power output and fuel consumption at each mode to permit calculation of brake specific emissions using a carbon balance method.

(2) The six engines were also subjected to an experimental EPA three-speed, multi-load operating schedule which included a much wider variety of operation than the nine-mode procedure. Instrumentation differences must also be accounted for as follows.

> (a) The CL method eliminates the troublesome chemical drier used in non-dispersive infrared (NDIR) analysis of nitric oxide and measures both nitric oxide and nitrogen dioxide. It is compatible with the light-duty regulations. There is one drawback and that is removal of the water of combustion from the exhaust sample. Currently an ice trap, which removes on the order of eleven percent of the NO_2, is used but could be eliminated by preparation of a heated CL. On engines evaluated in this and previous projects, NO_2 in raw gasoline engine exhaust has been less than a few percent.
>
> (b) The heated FID method is considered a vast improvement over the NDIR hydrocarbon analyzers used in the Federal nine-mode test. The NDIR method grossly understates exhaust hydrocarbons since they are sensitive to just normal paraffins and an ice trap is employed in the sample system. Although the FID system cannot be considered an absolute or total method, it is substantially better than NDIR and is consistent with the light-duty regulations. There are some slight drawbacks, such as the need for extended purge following a high HC level as occurs during closed throttle operation.

(3) The baseline emissions phase of the project required measurement of oxygenates. The best known method for repetitive samples is the

MBTH method, a wet collected colorimetric procedure that expresses aliphatic aldehydes as formaldehyde. Although the run-to-run repeatability seems satisfactory, the mode-to-mode repeatability was unacceptable. Generally only two of every three demonstrated acceptable ± 20 percent repeatability. The data thus reported must be judged in terms of the method and its precision. Certainly more needs to be done to develop a precise measurement of oxygenates on repetitive samples.

(4) The experimental EPA test method resulted in run-to-run repeatability as good as the nine-mode Federal Test. It is longer and more inclusive and easier to reduce and calculate in terms of a final answer. Precautions must be taken to obtain as accurate power and fuel rate measurements as when measuring exhaust contaminants. Measurement of flywheel power and fuel rate at light loads and lower engine speed is more difficult than at the higher loads and speed.

(5) Engines generally operate on the experimental EPA procedure without problem, although one of the six engines refused to operate at the lower engine speed. The exact selection of engine speeds, power levels, and their respective weighting factors were beyond the scope of this project. These rely on available road data from the operation of vehicles above 6,000-lb GVW. It is difficult to comment on those used in the experimental procedure without substantial additional data.

(6) Two engines, one popular V-8 engine from each group of three, were selected for evaluation of emission control technology. This phase of the study, intended to rely mostly on manufacturer's data and items developed for engines in heavy duty operation, was limited to factory-furnished light-duty items such as air injection (both engines) and EGR (one engine). This was supplemented by SwRI with a commercially-available platinum-type oxidation catalyst reactor and a laboratory manually-controlled EGR system. In addition to a study of these devices, the effect of basic spark timing and carburetor main jet size (air-fuel ratio) was studied. All these were studied singly and in combination to determine emission reduction. The goal was to obtain gross reductions in HC, CO and NO_x without an increase in fuel consumption nor decrease in power available.

(7) Gross reductions with the first engine exhaust emissions were achieved based on the experimental EPA test schedule. Hydrocarbons were reduced by 70 percent, carbon monoxide by 68 percent, oxides of nitrogen were lowered by 30 percent and oxygenates were reduced by 58 percent. Fuel consumption, in terms of weighted brake specific fuel consumption, was increased by 7.4 percent while maximum power was unchanged. Factory light-duty EGR and air injection, standard 1972 engine trim, and basic spark timing were retained. A commercially-available platinum-type oxidation catalyst played a key role in effecting the HC and CO reductions. Driveability and durability aspects have not been specifically determined, though

all the components have been proven in light-duty service. The platinum catalyst depends on lead-free gasoline for operation. Driveability should not be any more affected than light-duty vehicles with the same equipment, though this has yet to be established in a truck.

(8) Operating the first control-equipped engine on the Federal nine-mode procedure failed to give the same degree of emissions control as with the 23-mode EPA procedure. Relative to the experimental procedure, the nine-mode tended to understate the HC and overstate the CO and NO_x. For example, the 70 percent reduction in HC by the 23 mode test may be compared to no change in HC by the nine-mode test. A similar level of reduction in CO by the 23-mode test was found to give about a 90 percent CO reduction by the nine mode. NO_x, reduced 30 percent based on 23-mode data, was reduced by almost 60 percent. The light-duty EGR schedule, creating excessive HC, and the inability of the catalyst to reduce HC during the 19- and 16-inch modes is felt to be the major reason. Had the control-equipped engine been experimented with on the nine-mode schedule, a different combination of control devices would have been used in the 19- and 16-inch intake vacuum modes. From this it may be concluded that the type of test procedure can influence the design and development of an emissions control strategy.

(9) Based on the experimental EPA test procedure, HC was reduced by 85 percent, CO by 71 percent, NO_x by 51 percent and oxygenates by 53 percent with the second engine studied. The engine was operated with standard 1972 trim (carburetor, distributor and basic spark timing), but with light-duty air injection system. The air injection vacuum operation distribution valve was replaced with a simple pipe "Tee" and the same platinum-type commercially-available oxidation catalysts employed. Since no light-duty or heavy-duty EGR system was available from the manufacturer, a manually-controlled laboratory EGR system was employed. An EGR schedule was tailored to minimize NO_x while not seriously affecting HC, CO, power, and fuel consumption. These reductions had penalties in top-end performance at 2300 rpm (15 hp or 12 percent) with no loss in power at 1200 rpm. Weighted brake specific fuel consumption was increased by 13 percent. As with the first engine studied, no assessment of driveability or durability can be given. These were laboratory studies confined to engines operated on stationary dynamometers under constant speed-load engine "mapping"-type conditions.

(10) Operation of the second control-equipped engine on the nine-mode Federal schedule involved re-tailoring the EGR so that five percent was recirculated in the 5-inch mode and ten percent was recirculated in the 10-inch mode. No EGR was used at any other mode and the HC, CO, and NO_x reductions were on the same order of magnitude as obtained on the 23-mode test. The key to this was modifying the EGR schedule specifically for the nine-mode test. The oxidation catalyst seemed to do a better job on HC from this engine than on the first engine. The catalyst supplier

indicated that this was not surprising since the catalyst will preferentially accelerate oxidation of the olefins, aromatics, and certain paraffinic hydrocarbons.

(11) The objectives of the six engine baseline study were achieved and the merits of the experimental test procedure demonstrated. Likewise, the goals of the two engine control technology assessment portion of the project were met in that gross reductions in exhaust emissions were demonstrated. The substantial reductions did not come without a known fuel consumption penalty and an unknown driveability and durability penalty. Only two engines were involved in this limited assessment and much caution must be taken in control technology potentialities of all engines. It is generally true that each manufacturer's engine and even different displacements of a given make will respond differently to emission control strategies. However, limited laboratory demonstration has been made of control potentialities.

VI. RECOMMENDATIONS

This project must be termed a success since substantial reductions in emissions were demonstrated even though limited to three months of laboratory work, two months on one engine and one month on the other.

There were many items uncovered or made known during the last few months that could not be included in this time and fund-limited project. Advanced oxidation catalysts, newly announced oxidation-reduction catalysts, improved exhaust recirculation valves and control modules, turbochargers, to name a few, are still waiting to be considered in depth. And, the hurried nature of the tests conducted under this project could stand some replication and refinement as well as demonstration with additional engine makes and sizes. For example, the light-duty EGR system on one engine reduced NO_x, but more could have been achieved using a schedule tailored for the heavy-duty test procedure.

It is recommended that consideration be given to a long range project to continue research and development on a long term planned basis of control technology for heavy-duty gasoline engines. The intent of such a project would not be to do the manufacturer's job for him, but to demonstrate proof of principle and to evaluate the state of the art. In a way, the effort could act to provide stimulation to the engine manufacturers and those who manufacture control equipment. Those advantages would accrue in addition to the basic objective, namely, determine potential ways to reduce emissions from heavy-duty engines. In closing, the work reported herein represents a good start on what should be a long-range program.

LIST OF REFERENCES

1. 1971 Motor Truck Facts, Automobile Manufacturers Association, Inc.

2. Springer, Karl J., "An Investigation of Emissions from Trucks Above 6000-lb GVW Powered by Spark-Ignited Engines," Final Report to the U. S. Public Health Service, under Contract PH 86-67-72, March 1969.

3. Springer, K. J., Williams, G. L., Olsen, R. W., and Mills, K. D., "Emissions from Gasoline Powered Trucks Above 10,000-lb GVW Using PHS Proportional Sampling Techniques," AIChE Paper No. 53C, presented at the Sixty-First Annual Meeting, Los Angeles, California, December 1968.

4. Olsen, R. W. and Springer, K. J., "Exhaust Emissions from Heavy-Duty Vehicles," SAE Paper No. 690764, presented at the National Combined Fuels and Lubricants and Transportation Meetings, Houston, Texas, November 4-7, 1969.

5. Tyree, C. D. and Springer, K. J., "Studies of Emissions from Gasoline-Powered Vehicles Above 6,000-lb Gross Vehicle Weight," Final Report to the National Air Pollution Control Administration under Contract PH 86-67-72, July 1970.

6. Springer, K. J. and Tyree, C.D., "Exhaust Emissions from Gasoline-Powered Vehicles Above 6,000-lb Gross Vehicle Weight," Final Report to the Environmental Protection Agency under Contract EHS 70-110, April 1972.

7. Federal Register, Vol. 36, No. 219, Department of Health, Education and Welfare, November 10, 1970.

8. "California Exhaust Emission Standards Test and Approval Procedures For Engines in 1973 and Subsequent Model Gasoline-Powered Motor Vehicles over 6,001 Pounds Gross Vehicle Weight", State of California, Air Resources Board - Proposed November 18, 1970.

9. "Staff Discussion of Proposed Revision to the Heavy-Duty Gasoline Powered Vehicle Test Procedure", State of California, Air Resources Board, amended January 19, 1972.

10. Letter John J. McFadden to Karl J. Springer dated February 17, 1972, with attachment titled "Test Procedure for Heavy Duty Motor Vehicle Engines" dated February 17, 1972.

11. Springer, Karl J. and Dietzmann, Harry E., "Diesel Exhaust Hydrocarbon Measurement - A Flame Ionization Method," SAE Automotive Engineering Congress, Detroit, Michigan (January 1970).

12. Sawicki, E., et al., "The 3-Methyl-2-benzothiazolone Hydrazone Test," Anal. Chem., 33, pp. 93-96 (1961).

13. Hausen, T. R., "Determination of Aliphatic Aldehydes: 3-Methyl-2-benzothiazolone Hydrazone Hydrochloride Selected Methods," Anal. Chem., 33, p. F-1 (1961).

14. Krause, S. R., Ethyl Final Report to AMA titled "Effect of Engine Intake-Air Humidity, Temperature, and Pressure on Exhaust Emissions."

15. Spindt, R. S., SAE paper 650507 titled "Air-Fuel Ratios from Exhaust Gas Analysis."

16. Federal Register, Vol. 36, No. 193, Environmental Protection Agency, October 5, 1971.

APPENDIX A

EMISSION RESULTS FROM ENGINE 2-1

TABULAR FORM

ENGINE 2-1

NINE MODE FTP EMISSION RESULTS

CONCENTRATION BASIS

```
3-16-72          ENGINE 2-1          RUN 1
                                                                              A = .933     HUM =  58  GR/LB
------------------------------------------------------------------------------------------------------------
FEDERAL        CONCENTRATION AS MEASURED    DILUTION      A D J U S T E D     WEIGHTING      W E I G H T E D
MODE           HC     CO     CO2     NO      FACTOR      HC     CO     NO      FACTOR      HC      CO       NO
------------------------------------------------------------------------------------------------------------
CYCLE 1
  1 IDLE       119  2.415  12.630   117      1.036      124  2.507   121      .036       4.448   .090    4.373
  2 16'HG       90   .185  13.950  2252      1.025       92   .190  2309      .089       8.214   .017  205.535
  3 10'HG       30   .143  13.350  2088      1.078       32   .154  2246      .257       8.309   .040  577.232
  4 16'HG       80   .234  13.950  2306      1.024       82   .245  2362      .089       7.293   .022  210.223
  5 19'HG       70   .513  14.070   891      1.007       70   .516   897      .047       3.312   .024   42.152
  6 16'HG       78   .191  13.950  2378      1.026       80   .196  2440      .089       7.124   .017  217.198
  7  3'HG       39   .500  13.740  2263      1.033       40   .517  2338      .283      11.405   .146  661.783
  8 16'HG       76   .264  14.010  2414      1.019       77   .269  2461      .089       6.895   .024  219.014
  9 C.T.       980   .335   6.210    72      1.950     1911   .653   140      .021      40.131   .014    2.948
  SUM------------(CYCLE COMPOSITE)-------------------------------------------------    97.132   .394 2140.458
CYCLE 2
  1 IDLE       119  2.415  12.630   117      1.038      124  2.507   121      .036       4.448   .090    4.373
  2 16'HG       83   .187  13.980  2263      1.024       85   .191  2317      .089       7.563   .017  206.197
  3 10'HG       28   .143  13.460  2150      1.069       30   .153  2299      .257       7.694   .039  590.778
  4 16'HG       75   .208  13.980  2428      1.024       77   .213  2485      .089       6.833   .019  221.203
  5 19'HG       74   .588  14.110   943      1.001       74   .589   944      .047       3.482   .028   44.370
  6 16'HG       78   .205  13.970  2419      1.024       80   .210  2478      .089       7.110   .019  220.511
  7  3'HG       40   .612  13.790  2294      1.026       41   .628  2353      .283      11.609   .178  665.768
  8 16'HG       78   .225  13.990  2456      1.022       80   .230  2510      .089       7.095   .020  223.411
  9 C.T.      1010   .261   6.590    85      1.856     1875   .484   158      .021      39.372   .010    3.313
  SUM------------(CYCLE COMPOSITE)-------------------------------------------------    95.205   .420 2179.924
CYCLE 3
  1 IDLE        54   .170  14.310   111      1.078       58   .183   120      .036       2.095   .007    4.307
  2 16'HG       84   .189  13.920  2267      1.028       86   .194  2330      .089       7.685   .017  207.410
  3 10'HG       20   .144  13.300  2110      1.083       22   .156  2284      .257       5.565   .040  587.065
  4 16'HG       75   .188  13.940  2406      1.027       77   .193  2472      .089       6.857   .017  219.975
  5 19'HG       73   .517  14.020   940      1.010       74   .522   949      .047       3.465   .025   44.619
  6 16'HG       62   .205  13.920  2414      1.029       64   .211  2484      .089       5.679   .019  221.106
  7  3'HG       40   .562  13.670  2328      1.036       41   .582  2412      .283      11.729   .165  682.636
  8 16'HG       70   .217  13.840  2415      1.034       72   .224  2497      .089       6.441   .020  222.229
  9 C.T.       934   .292   6.980    97      1.782     1665   .520   173      .021      34.962   .011    3.631
  SUM------------(CYCLE COMPOSITE)-------------------------------------------------    84.478   .320 2192.978
CYCLE 4
  1 IDLE        54   .170  13.310   111      1.078       58   .183   120      .036       2.095   .007    4.307
  2 16'HG       85   .176  13.880  2398      1.031       88   .182  2473      .089       7.802   .016  220.104
  3 10'HG       26   .147  13.260  2134      1.085       28   .160  2316      .257       7.251   .041  595.165
  4 16'HG       71   .195  13.800  2354      1.038       74   .202  2443      .089       6.557   .018  217.389
  5 19'HG       70   .461  13.990  1016      1.014       71   .468  1030      .047       3.337   .022   48.433
  6 16'HG       77   .186  13.900  2370      1.030       79   .192  2441      .089       7.059   .017  217.281
  7  3'HG       39   .595  13.720  2329      1.031       40   .614  2402      .283      11.383   .174  679.752
  8 16'HG       73   .222  13.980  2475      1.023       75   .227  2533      .089       6.648   .020  225.407
  9 C.T.       974   .258   6.740    94      1.831     1783   .472   172      .021      37.443   .010    3.614
  SUM------------(CYCLE COMPOSITE)-------------------------------------------------    89.576   .325 2211.453

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------    96.169   .407 2160.191

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------    87.027   .322 2202.215

 FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC   0.35*(   96.169) + 0.65*(   87.027) =    90.226  PPM
                                             CO   0.35*(     .407) + 0.65*(     .322) =      .352  PERCENT
                                             NO   0.35*( 2160.191) + 0.65*( 2202.215) =  2187.507  PPM
                                                                       CORRECTED NO =  2040.536  PPM

 DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.4*HC)
```

```
3-16-72          ENGINE P-1           RUN 2                             K = .974      HUM =  58  GR/LB
----------------------------------------------------------------------------------------------------------
FEDERAL          CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D     WEIGHTING        W E I G H T E D
MODE               HC      CO     CO2     NO    FACTOR      HC      CO     NO     FACTOR          HC      CO       NO
----------------------------------------------------------------------------------------------------------
CYCLE 1
         1 IDLE       81   .167  13.650    92    1.049       85   .175    102     .036         3.059   .006     3.664
         2 16'HG      66   .152  14.140  2014    1.013       67   .154   2045     .089         7.256   .014   182.001
         3 10'HG      32   .140  13.440  1685    1.071       34   .139   2019     .257         8.807   .036   518.810
         4 16'HG      78   .164  14.160  2215    1.012       79   .166   2242     .089         7.026   .015   199.526
         5 19'HG      76   .432  14.360   876     .989       75   .427    867     .047         3.533   .020    40.728
         6 16'HG      83   .168  13.990  2226    1.024       85   .172   2279     .089         7.562   .015   202.819
         7  3'HG      48   .562  13.900  2144    1.019       49   .573   2184     .283        13.939   .162   618.141
         8 16'HG      73   .185  14.070  2281    1.018       74   .188   2322     .089         6.615   .017   206.696
         9 C.T.      978   .233   6.400    81    1.915     1873   .446    155     .021        39.325   .009     3.257
         SUM------------(CYCLE COMPOSTIE)-------------------------------------------        97.524   .294  1975.641
CYCLE 2
         1 IDLE       81   .167  13.650    97    1.049       85   .175    102     .036         3.059   .006     3.664
         2 16'HG      88   .146  13.990  2104    1.024       90   .150   2155     .089         8.021   .013   191.779
         3 10'HG      29   .139  13.440  1961    1.071       31   .149   2100     .257         7.981   .038   539.677
         4 16'HG      73   .170  13.990  2193    1.024       75   .174   2247     .089         6.656   .016   199.950
         5 19'HG      75   .439  14.140   813    1.004       75   .441    816     .047         3.540   .021    38.368
         6 16'HG      76   .180  13.790  2188    1.039       79   .187   2272     .089         7.025   .017   202.234
         7  3'HG      44   .571  13.770  2197    1.028       45   .587   2259     .283        12.803   .166   639.252
         8 16'HG      76   .189  13.930  2255    1.028       78   .194   2318     .089         6.953   .017   206.292
         9 C.T.      924   .219   6.310    89    1.955     1806   .428    174     .021        37.932   .009     3.654
         SUM------------(CYCLE COMPOSITE)-------------------------------------------        93.969   .303  2024.871
CYCLE 3
         1 IDLE       55   .155  13.320   101    1.078       59   .167    109     .036         2.133   .006     3.918
         2 16'HG      83   .149  13.870  2156    1.033       86   .154   2228     .089         7.632   .014   198.254
         3 10'HG      36   .139  13.250  1950    1.085       39   .151   2128     .257        10.043   .039   546.768
         4 16'HG      82   .179  13.920  2263    1.029       84   .184   2328     .089         7.506   .016   207.149
         5 19'HG      83   .545  14.060   885    1.005       83   .548    890     .047         3.922   .026    41.820
         6 16'HG      83   .155  13.780  2254    1.040       86   .161   2343     .089         7.680   .014   208.558
         7  3'HG      47   .494  13.670  2201    1.038       49   .513   2285     .283        13.808   .145   646.618
         8 16'HG      73   .176  13.820  2301    1.037       76   .182   2385     .089         6.735   .016   212.302
         9 C.T.      902   .214   6.140    95    2.008     1811   .430    191     .021        38.035   .009     4.006
         SUM------------(CYCLE COMPOSITE)-------------------------------------------        97.495   .285  2069.393
CYCLE 4
         1 IDLE       55   .155  13.320   101    1.078       59   .167    109     .036         2.133   .006     3.918
         2 16'HG      73   .163  13.640  2210    1.051       77   .171   2322     .089         6.826   .015   206.662
         3 10'HG      27   .137  13.040  1936    1.104       30   .151   2137     .257         7.659   .039   549.147
         4 16'HG      69   .151  13.630  2270    1.052       73   .159   2389     .089         6.462   .014   212.586
         5 19'HG      76   .443  13.920   876    1.019       77   .452    893     .047         3.641   .021    41.972
         6 16'HG      67   .152  13.720  2244    1.046       70   .159   2346     .089         6.235   .014   208.812
         7  3'HG      45   .532  13.560  2168    1.045       47   .556   2287     .283        13.309   .157   647.115
         8 16'HG      74   .173  13.720  2339    1.044       77   .181   2442     .089         6.877   .016   217.369
         9 C.T.      931   .222   6.350   103    1.942     1808   .431    200     .021        37.968   .009     4.201
         SUM------------(CYCLE COMPOSITE)-------------------------------------------        91.111   .292  2091.781

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------        95.746   .299  2000.256

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------        94.303   .289  2080.587

         FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(   95.746) + 0.65*(   94.303) =     94.808  PPM
                                                     CO    0.35*(     .299) + 0.65*(     .289) =       .292  PERCENT
                                                     NO    0.35*( 2000.256) + 0.65*( 2080.587) =   2052.471  PPM
                                                                                CORRECTED NO =   1998.158  PPM

         DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
3-06-72         ENGINE 2-1          RUN 3                                        K = .981     HUM =  70  GR/LB
--------------------------------------------------------------- ----------------------------------------------------------------------
FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING        W E I G H T E D
MODE           HC      CO    CO2     NO      FACTOR     HC     CO    NO      FACTOR        HC      CO        NO
----------------------------------------------------------------------------------------------------------------------------------
CYCLE 1
      1 IDLE          47   .151  13.900      95     1.034       49   .156     98     .036        1.749   .006      3.536
      2 16'HG         75   .149  14.250    2103     1.007       75   .150   2117     .089        6.719   .013    188.395
      3 10'HG         27   .135  13.740    1992     1.048       28   .141   2087     .257        7.272   .036    536.487
      4 16'HG         66   .170  14.320    2242     1.002       66   .170   2246     .089        5.884   .015    199.865
      5 19'HG         73   .437  14.470     916      .982       72   .429    899     .047        3.369   .020     42.273
      6 16'HG         73   .185  14.320    2262     1.001       73   .185   2263     .089        6.501   .016    201.438
      7  3'HG         43   .570  14.210    2244      .997       43   .568   2238     .283       12.134   .161    633.242
      8 16'HG         74   .202  14.380    2363      .996       74   .201   2353     .089        6.558   .018    209.427
      9 C.T.         522   .214   6.690     130     1.970     1028   .422    256     .021       21.594   .009      5.378
      SUM------------(CYCLE COMPOSITE)------------------------------------------------------    71.780   .295   2020.040
CYCLE 2
      1 IDLE          47   .151  13.900      95     1.034       49   .156     98     .036        1.749   .006      3.536
      2 16'HG         83   .171  14.290    2268     1.002       83   .171   2273     .089        7.405   .015    202.338
      3 10'HG         22   .134  13.650    2027     1.055       23   .141   2139     .257        5.966   .036    549.723
      4 16'HG         68   .173  14.060    2304     1.020       69   .176   2349     .089        6.171   .016    209.095
      5 19'HG         76   .465  14.340     946      .989       75   .460    936     .047        3.534   .022     43.993
      6 16'HG         67   .165  14.200    2328     1.010       68   .167   2352     .089        6.023   .015    209.287
      7  3'HG         43   .604  14.150    2215     1.000       43   .604   2215     .283       12.170   .171    626.912
      8 16'HG         70   .204  14.260    2368     1.004       70   .205   2378     .089        6.257   .018    211.663
      9 C.T.         642   .249   5.820      91     2.184     1402   .544    199     .021       29.451   .011      4.174
      SUM------------(CYCLE COMPOSITE)------------------------------------------------------    78.727   .310   2060.721
CYCLE 3
      1 IDLE          49   .176  13.490     104     1.064       52   .187    111     .036        1.876   .007      3.983
      2 16'HG         67   .169  14.090    2286     1.016       68   .172   2323     .089        7.869   .015    206.756
      3 10'HG         29   .138  13.510    2102     1.065       31   .147   2239     .257        7.940   .038    575.527
      4 16'HG         70   .165  14.060    2355     1.020       71   .168   2402     .089        6.354   .015    213.751
      5 19'HG         70   .420  14.310     949      .993       70   .417    943     .047        3.268   .020     44.311
      6 16'HG         78   .183  14.170    2318     1.011       79   .185   2343     .089        7.017   .016    208.520
      7  3'HG         35   .489  13.980    2173     1.017       36   .497   2209     .283       10.070   .141    625.208
      8 16'HG         62   .163  14.090    2284     1.018       63   .166   2326     .089        5.619   .015    207.010
      9 C.T.         704   .203   6.740     115     1.907     1343   .387    219     .021       28.200   .008      4.606
      SUM------------(CYCLE COMPOSITE)------------------------------------------------------    78.213   .274   2089.671
CYCLE 4
      1 IDLE          49   .176  13.490     104     1.064       52   .187    111     .036        1.876   .007      3.983
      2 16'HG         79   .168  13.950    2162     1.027       81   .173   2220     .089        7.221   .015    197.606
      3 10'HG         30   .138  13.200    2027     1.090       33   .150   2210     .257        8.405   .039    567.881
      4 16'HG         73   .163  13.990    2282     1.032       75   .168   2355     .089        6.705   .015    209.598
      5 19'HG         72   .458  14.130     825     1.004       72   .460    829     .047        3.399   .022     38.945
      6 16'HG         71   .159  13.780    2306     1.040       74   .165   2399     .089        6.575   .015    213.537
      7  3'HG         40   .551  13.820    2188     1.026       41   .565   2244     .283       11.609   .160    635.027
      8 16'HG         73   .202  14.040    2359     1.020       74   .206   2405     .089        6.625   .018    214.087
      9 C.T.         754   .198   6.010      94     2.094     1579   .415    197     .021       33.162   .009      4.134
      SUM------------(CYCLE COMPOSITE)------------------------------------------------------    85.577   .249   2084.799

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------    75.253   .302   2040.381

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------    81.895   .287   2087.235

      FOUR CYCLE COMPOSITE - REPORTED VALUES -     HC    0.35*(   75.253) + 0.65*(   81.895) =    79.570  PPM
                                                   CO    0.35*(     .302) + 0.65*(     .287) =      .292  PERCENT
                                                   NO    0.35*( 2040.381) + 0.65*( 2087.235) =  2070.836  PPM
                                                                                CORRECTED NO =  2032.029  PPM

      DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

ENGINE 2-1

NINE MODE FTP EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
3-06-77          ENGINE 2-1          RUN 1                               K =  .94      HUM =  58  GR/LB
--------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED      TOTAL    FUEL      ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
MODE            HC      CO      CO2     NO   CARBON   CONS.      HC      CO    NO2   FACT.      HC      CO   NO2(K)  HP
--------------------------------------------------------------------------------------------------------------

CYCLE 1
    1 IDLE      119   2.415  12.63    117   15.174    1639      14     527      4   .232      3.2     122     1.0    0
    2 16 HG      90    .185  13.95   2252   14.232    5970      41     157    314   .077      3.1      12    24.1   18
    3 10 HG      30    .143  13.35   2084   13.525    8626      21     184    441   .147      3.0      27    64.9   32
    4 16 HG      80    .239  13.95   2306   14.275    5970      36     202    320   .077      2.8      16    24.7   18
    5 19 HG      70    .513  14.07    891   14.659    4622      24     327     93   .057      1.4      19     5.3    8
    6 16 HG      78    .191  13.95   2378   14.225    5970      35     162    331   .077      2.7      12    25.5   18
    7  3 HG      39    .500  13.74   2263   14.282   12848      38     909    676   .113      4.3     103    76.4   50
    8 16 HG      76    .264  14.01   2414   14.356    5970      34     222    333   .077      2.6      17    25.7   18
    9 C.T.      980    .335   6.21     72    7.603    1732     241     154      5   .143     34.5      22      .8    0
    SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.5      21    15.2

CYCLE 2
    1 IDLE      119   2.415  12.63    117   15.174    1639      14     527      4   .232      3.2     122     1.0    0
    2 16 HG      83    .187  13.98   2263   14.257    5970      38     158    315   .077      2.9      12    24.2   18
    3 10 HG      28    .143  13.46   2150   13.633    8626      19     183    452   .147      2.8      27    66.4   32
    4 16 HG      75    .208  13.98   2428   14.269    5970      34     176    337   .077      2.6      14    26.0   18
    5 19 HG      74    .588  14.11    943   14.778    4622      25     371     98   .057      1.4      21     5.6    8
    6 16 HG      78    .205  13.97   2419   14.259    5970      35     173    336   .077      2.7      13    25.9   18
    7  3 HG      40    .612  13.79   2294   14.445   12848      38    1100    677   .113      4.3     124    76.5   50
    8 16 HG      74    .225  13.99   2456   14.299    5970      35     190    340   .077      2.7      15    26.2   18
    9 C.T.     1010    .261   6.59     85    7.942    1732     238     115      6   .143     34.0      16      .9    0
    SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.5      22    15.5

CYCLE 3
    1 IDLE       54    .170  13.31    111   13.538    1639       7      42      4   .232      1.6      10     1.0    0
    2 16 HG      84    .189  13.92   2267   14.200    5970      38     161    316   .077      2.9      12    24.4   18
    3 10 HG      20    .144  13.30   2110   13.466    8626      14     186    449   .147      2.0      27    66.0   32
    4 16 HG      75    .188  13.94   2406   14.209    5970      34     160    336   .077      2.6      12    25.8   18
    5 19 HG      73    .517  14.02    940   14.616    4622      25     330     99   .057      1.4      19     5.6    8
    6 16 HG      62    .205  13.92   2414   14.192    5970      28     174    337   .077      2.2      13    26.0   18
    7  3 HG      40    .562  13.67   2328   14.275   12848      39    1022    696   .113      4.4     115    78.6   50
    8 16 HG      70    .217  13.84   2415   14.133    5970      32     185    339   .077      2.5      14    26.1   18
    9 C.T.      934    .292   6.98     97    8.281    1732     211     123      7   .143     30.2      18     1.0    0
    SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.1      15    15.6

CYCLE 4
    1 IDLE       54    .170  13.31    111   13.538    1639       7      42      4   .232      1.6      10     1.0    0
    2 16 HG      85    .176  13.88   2398   14.148    5970      39     150    336   .077      3.0      12    25.9   18
    3 10 HG      26    .147  13.26   2134   13.435    8626      18     191    455   .147      2.7      28    66.9   32
    4 16 HG      71    .195  13.80   2354   14.072    5970      33     167    332   .077      2.5      13    25.5   18
    5 19 HG      70    .461  13.99   1016   14.527    4622      24     296    107   .057      1.4      17     6.1    8
    6 16 HG      77    .186  13.90   2370   14.169    5970      35     158    332   .077      2.7      12    25.5   18
    7  3 HG      39    .595  13.72   2329   14.357   12848      38    1076    692   .113      4.3     122    78.2   50
    8 16 HG      73    .222  13.99   2475   14.281    5970      33     187    344   .077      2.5      14    26.5   18
    9 C.T.      974    .258   6.74     94    8.050    1732     226     112      7   .143     32.4      16     1.0    0
    SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.3      15    15.8

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------      3.5      22    15.4

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------      3.2      15    15.7

    FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.5) + 0.65(     3.2) =    3.281  (MASS)
                                             CO  0.35(      22) + 0.65(      15) =     17.3  (MASS)
                                             NO2 0.35(    15.4) + 0.65(    15.7) =   15.579  (MASS)
                                                                 CORRECTED NO2 =   14.623  (MASS)
```

```
3-06-72        ENGINE 2-1         RUN 2                                     K =  .98     HUM =  68  GR/LB
-------------------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED       TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
MODE           HC      CO      CO2     NO    CARBON   CONS.      HC      CO     NO2    FACT.      HC      CO   NO2(K)  HP
-------------------------------------------------------------------------------------------------------------------------

CYCLE 1
        1 IDLE        81    .167   13.65     97   13.904    1639      10      40      4   .232      2.4      9      .9    0
        2 16 HG       86    .152   14.14   2018   14.385    5970      39     127    278   .077      3.0     10    21.4   18
        3 10 HG       32    .130   13.44   1885   13.605    8626      22     167    397   .147      3.2     24    58.3   32
        4 16 HG       28    .164   14.16   2215   14.408    5970      35     137    305   .077      2.7     11    23.5   18
        5 19 HG       76    .432   14.36    876   14.874    4622      26     271     90   .057      1.5     15     5.2    8
        6 16 HG       83    .168   13.99   2226   14.248    5970      38     142    310   .077      2.9     11    23.8   18
        7  3 HG       48    .562   13.90   2144   14.514   12848      46    1005    630   .113      5.2    114    71.2   50
        8 16 HG       73    .185   14.07   2281   14.334    5970      33     156    315   .077      2.5     12    24.3   18
        9 C.T.       978    .233    6.40     81    7.689    1732     238     106      6   .143     34.0     15      .9    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------      3.5     14    14.1

CYCLE 2
        1 IDLE        81    .167   13.65     97   13.904    1639      10      40      4   .232      2.4      9      .9    0
        2 16 HG       88    .146   13.99   2104   14.231    5970      40     124    293   .077      3.1     10    22.6   18
        3 10 HG       29    .139   13.44   1961   13.610    8626      20     178    413   .147      2.9     26    60.7   32
        4 16 HG       73    .170   13.99   2193   14.239    5970      33     144    305   .077      2.5     11    23.5   18
        5 19 HG       75    .439   14.14    813   14.660    4622      26     280     85   .057      1.5     16     4.9    8
        6 16 HG       76    .180   13.79   2188   14.052    5970      35     154    309   .077      2.7     12    23.8   18
        7  3 HG       44    .571   13.77   2197   14.389   12848      42    1030    651   .113      4.8    116    73.6   50
        8 16 HG       76    .189   13.93   2255   14.201    5970      35     160    315   .077      2.7     12    24.2   18
        9 C.T.       924    .219    6.31     89    7.527    1732     230     102      7   .143     32.8     15     1.0    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------      3.4     14    14.4

CYCLE 3
        1 IDLE        55    .155   13.32    101   13.534    1639       7      38      4   .232      1.7      9      .9    0
        2 16 HG       83    .149   13.87   2156   14.109    5970      38     127    303   .077      2.9     10    23.3   18
        3 10 HG       36    .139   13.25   1960   13.428    8626      25     180    418   .147      3.7     27    61.4   32
        4 16 HG       82    .179   13.92   2263   14.188    5970      37     152    316   .077      2.9     12    24.3   18
        5 19 HG       83    .545   14.06    885   14.695    4622      28     346     92   .057      1.6     20     5.3    8
        6 16 HG       83    .155   13.78   2254   14.025    5970      38     133    319   .077      2.9     10    24.5   18
        7  3 HG       47    .494   13.67   2201   14.215   12848      46     902    660   .113      5.2    102    74.6   50
        8 16 HG       73    .176   13.82   2301   14.075    5970      33     151    324   .077      2.6     12    25.0   18
        9 C.T.       902    .214    6.14     95    7.328    1732     230     102      7   .143     32.9     15     1.1    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------      3.5     13    14.8

CYCLE 4
        1 IDLE        55    .155   13.32    101   13.534    1639       7      38      4   .232      1.7      9      .9    0
        2 16 HG       73    .163   13.64   2210   13.882    5970      34     142    316   .077      2.6     11    24.3   18
        3 10 HG       27    .137   13.04   1936   13.206    8626      19     181    420   .147      2.8     27    61.7   32
        4 16 HG       69    .151   13.63   2270   13.856    5970      32     131    325   .077      2.5     10    25.0   18
        5 19 HG       76    .443   13.92    876   14.445    4622      26     286     93   .057      1.5     16     5.3    8
        6 16 HG       67    .152   13.72   2244   13.944    5970      31     131    319   .077      2.4     10    24.6   18
        7  3 HG       45    .532   13.56   2188   14.141   12848      44     976    660   .113      5.0    110    74.6   50
        8 16 HG       74    .173   13.72   2339   13.973    5970      34     149    332   .077      2.6     11    25.5   18
        9 C.T.       931    .222    6.35    103    7.577    1732     230     103      8   .143     32.9     15     1.1    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------      3.3     13    14.9

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------------      3.5     14    14.3

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------------      3.4     13    14.8

        FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.5) + 0.65(     3.4) =    3.411  (MASS)
                                                 CO  0.35(      14) + 0.65(      13) =     13.5  (MASS)
                                                 NO2 0.35(    14.3) + 0.65(    14.8) =   14.639  (MASS)
                                                                   CORRECTED NO2 =   14.289  (MASS)
```

```
3-06-72          ENGINE 2-1          RUN 3                            K =  .98     HUM =  70  GR/LH
---------------------------------------------------------------------------------------------------------
MASS         CONCENTRATION AS MEASURED    TOTAL    FUEL     ADJUSTED (MASS)      WT.      WEIGHTED (MASS)
MODE           HC     CO      CO2    NO   CARBON   CONS.     HC      CO    NO2   FACT.     HC      CO   NO2(K)  HP
---------------------------------------------------------------------------------------------------------

CYCLE 1
      1 IDLE     47   .151  13.90    95   14.102    1639      6      35      4   .232     1.4      8      .9    0
      2 16 HG    75   .149  14.25  2103   14.480    5970     33     124    288   .077     2.6     10    22.2   18
      3 10 HG    27   .135  13.74  1992   13.904    8626     18     169    410   .147     2.7     25    60.3   32
      4 16 HG    66   .120  14.32  2242   14.561    5970     29     141    305   .077     2.3     11    23.5   18
      5 19 HG    73   .437  14.47   916   14.986    4622     24     272     94   .057     1.4     16     5.3    8
      6 16 HG    73   .185  14.32  2262   14.584    5970     32     153    307   .077     2.5     12    23.7   18
      7  3 HG    43   .570  14.21  2244   14.826   12848     40     998    646   .113     4.5    113    73.0   50
      8 16 HG    74   .202  14.38  2363   14.662    5970     33     166    319   .077     2.5     13    24.6   18
      9 C.T.    522   .214   6.69   130    7.468    1732    131     100     10   .143    18.7     14     1.4    0
      SUM-----------(CYCLE COMPOSITE)-----------------------------------------------     2.4     14    14.4

CYCLE 2
      1 IDLE     47   .151  13.90    95   14.102    1639      6      35      4   .232     1.4      8      .9    0
      2 16 HG    83   .171  14.29  2268   14.551    5970     37     142    309   .077     2.8     11    23.8   18
      3 10 HG    22   .134  13.65  2027   13.808    8626     15     169    420   .147     2.2     25    61.8   32
      4 16 HG    68   .173  14.06  2304   14.306    5970     31     146    319   .077     2.4     11    24.6   18
      5 19 HG    76   .465  14.34   946   14.887    4622     25     292     98   .057     1.5     17     5.6    8
      6 16 HG    67   .165  14.20  2328   14.437    5970     30     138    320   .077     2.3     11    24.6   18
      7  3 HG    43   .604  14.15  2215   14.800   12848     40    1059    638   .113     4.6    120    72.1   50
      8 16 HG    70   .204  14.26  2368   14.540    5970     31     169    323   .077     2.4     13    24.9   18
      9 C.T.    642   .249   5.82    91    6.762    1732    178     129      8   .143    25.4     18     1.1    0
      SUM-----------(CYCLE COMPOSITE)-----------------------------------------------     2.8     14    14.7

CYCLE 3
      1 IDLE     49   .176  13.49   104   13.719    1639      6      42      4   .232     1.5     10     1.0    0
      2 16 HG    87   .169  14.09  2286   14.353    5970     39     142    316   .077     3.0     11    24.3   18
      3 10 HG    29   .138  13.51  2102   13.679    8626     20     176    440   .147     2.9     26    64.7   32
      4 16 HG    70   .165  14.06  2355   14.301    5970     32     139    326   .077     2.4     11    25.1   18
      5 19 HG    70   .420  14.31   949   14.806    4622     24     265     98   .057     1.3     15     5.6    8
      6 16 HG    78   .183  14.17  2318   14.437    5970     35     153    318   .077     2.7     12    24.5   18
      7  3 HG    35   .489  13.98  2173   14.507   12848     33     875    639   .113     3.8     99    72.2   50
      8 16 HG    62   .163  14.09  2284   14.320    5970     28     137    316   .077     2.1     11    24.3   18
      9 C.T.    704   .203   6.74   115    7.703    1732    171      92      9   .143    24.4     13     1.2    0
      SUM-----------(CYCLE COMPOSITE)-----------------------------------------------     2.7     13    14.9

CYCLE 4
      1 IDLE     49   .176  13.49   104   13.719    1639      6      42      4   .232     1.5     10     1.0    0
      2 16 HG    79   .168  13.95  2162   14.203    5970     36     143    302   .077     2.8     11    23.2   18
      3 10 HG    30   .138  13.20  2027   13.370    8626     21     180    434   .147     3.1     26    63.8   32
      4 16 HG    73   .163  13.89  2282   14.132    5970     33     139    320   .077     2.6     11    24.6   18
      5 19 HG    72   .458  14.13   825   14.666    4622     25     292     86   .057     1.4     17     4.9    8
      6 16 HG    71   .159  13.78  2306   14.016    5970     33     137    326   .077     2.5     11    25.1   18
      7  3 HG    40   .551  13.82  2188   14.414   12848     39     992    647   .113     4.4    112    73.2   50
      8 16 HG    73   .202  14.04  2359   14.321    5970     33     170    326   .077     2.5     13    25.1   18
      9 C.T.    754   .198   6.01    94    7.022    1732    201      99      8   .143    28.7     14     1.1    0
      SUM-----------(CYCLE COMPOSITE)-----------------------------------------------     3.0     14    14.9

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------     2.6     14    14.6

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------     2.9     13    14.9

      FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(    2.6) + 0.65(    2.9) =    2.763  (MASS)
                                               CO  0.35(     14) + 0.65(     13) =     13.5  (MASS)
                                               NO2 0.35(   14.6) + 0.65(   14.9) =   14.773  (MASS)
                                                              CORRECTED NO2 =   14.522  (MASS)
```

ENGINE 2-1

EXPERIMENTAL 23 MODE EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
                              PROJECT 11-2877-01  CONTROL TECHNOLOGY
    3-08-72 RUN 2                                 ENGINE 2-1             STATIONARY DYNAMOMETER
------------------------------------------------------------------------------------------------------
                DYNA.        MAN.    FUEL RATE                     DRY CONCENTRATION
MODE  SPEED     LOAD    HP   VAC.  LB/HR   GM/HR     ALDE.      HC        CO       CO2       NO
------------------------------------------------------------------------------------------------------
  1    700       0.0     0   17.5    4.0    1810        0       682      .130     12.71      151
  2   1200       2.7     1   19.9    5.7    2604        0      2472     1.590     14.05      109
  3   1200      10.8     2   19.4    6.0    2717        0      2679     1.590     14.05      146
  4   1200      24.3     6   18.3    6.9    3130        0      2832     1.300     14.05      330
  5   1200      33.8     8   17.2    7.6    3452        0      2593      .520     14.31     1787
  6   1200      67.5    15   12.6    9.9    4504        0      2129      .130     14.18     1650
  7   1200     101.2    23    4.9   15.4    6985        0       581      .130     13.77     1563
  8   1200     110.7    25    3.3   16.2    7348        0       609      .130     13.77     1925
  9   1200     124.2    28    2.2   18.5    8380        0      1007      .150     14.05     2300
 10   1200     135.0    31    0.0   23.3   10569        0      4030    10.400      8.14       80
 11    700       0.0     0   17.6    4.0    1805        0       742      .130     13.33       68
 12   1200       0.0     0   21.5    4.0    1823        0     28965      .250      3.20       11
 13   2300     161.0    71     .9   44.0   19958        0      2941     6.070     11.01      510
 14   2300     148.1    65    2.3   36.0   16330        0      1486     2.140     13.33     1737
 15   2300     132.0    58    3.4   31.8   14424        0       875      .740     14.05     2350
 16   2300     120.7    53    4.7   29.0   13132        0       533      .350     14.05     2400
 17   2300      80.5    35   10.6   20.7    9412        0       518      .150     13.48     2900
 18   2300      40.2    18   16.7   14.4    6509        0      1709      .210     14.05     2500
 19   2300      29.0    13   18.2   12.5    5670        0      1620      .280     14.05     1675
 20   2300      12.9     6   20.2   10.4    4695        0      1453      .420     14.18      770
 21   2300       3.2     1   21.2    9.1    4128        0      1444      .640     14.18      420
 22    700       0.0     0   17.6    3.7    1656        0       726      .100     12.59       63
 23   2300       0.0     0   24.8    3.8    1737        0     17539      .130      3.56        7
------------------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR                WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE  ALDE.     HC       CO      NO2     FAC.       HP   ALDE.       HC       CO      NO2
------------------------------------------------------------------------------------------------------
  1    0.0      9.6      37      7.0     .070      0.0      I         R        R        R
  2    0.0     40.5     526      5.9     .060       .0    0.0     65.68    853.2      9.6
  3    0.0     45.7     549      8.3     .060       .1    0.0     18.54    222.3      3.4
  4    0.0     56.7     526     21.9     .050       .3    0.0     10.21     94.7      4.0
  5    0.0     59.3     240    135.8     .030       .2    0.0      7.69     31.2     17.6
  6    0.0     66.0      81    169.9     .060       .9    0.0      4.28      5.3     11.0
  7    0.0     29.1     131    259.6    0.000      0.0    0.0      1.26      5.7     11.2
  8    0.0     32.1     138    336.4     .040      1.0    0.0      1.27      5.5     13.3
  9    0.0     59.0     178    447.5    0.000      0.0    0.0      2.08      6.3     15.8
 10    0.0    224.8   11721     14.9    0.000      0.0    0.0      7.29    380.0       .5
 11    0.0      9.9      35      3.0     .070      0.0      I         R        R        R
 12    0.0    967.1     125       .9     .120      0.0      I         R        R        R
 13    0.0    337.9   14085    194.5     .025      1.8    0.0      4.79    199.8      2.8
 14    0.0    155.4    4520    603.1     .055      3.6    0.0      2.40     69.7      9.3
 15    0.0     84.9    1449    756.4     .035      2.0    0.0      1.47     25.1     13.1
 16    0.0     48.4     642    723.9     .060      3.2    0.0       .92     12.1     13.7
 17    0.0     35.6     208    662.3     .060      2.1    0.0      1.01      5.9     18.8
 18    0.0     77.1     191    374.4    0.000      0.0    0.0      4.37     10.9     21.2
 19    0.0     63.4     221    217.6     .065       .8    0.0      4.99     17.4     17.1
 20    0.0     46.3     270     81.4    0.000      0.0    0.0      8.20     47.9     14.4
 21    0.0     39.8     357     38.5    0.000      0.0    0.0     28.25    252.9     27.3
 22    0.0      9.4      26      2.7     .080      0.0      I         R        R        R
 23    0.0    559.7      84       .7     .060      0.0      I         R        R        R

CYCLE COMPOSITE     HC      12.170     GRAM/BHP HR
                    CO      52.955     GRAM/BHP HR
                    NO2     11.962     GRAM/BHP HR
                    ALDE     0.000     GRAM/BHP HR
                    BSFC      .750       LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-09-72 RUN 1                      ENGINE 2-1           STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------
                DYNA.          MAN.   FUEL  RATE              DRY  CONCENTRATION
MODE  SPEED     LOAD     HP    VAC.  LB/HR  GM/HR     ALDE.     HC       CO       CO2      NO
-----------------------------------------------------------------------------------
  1    700       0.0      0    17.6    4.0   1810       11    1114     .150    12.22      63
  2   1200       2.7      1    20.2    5.7   2604       11    2042    1.450    13.77     115
  3   1200      10.8      2    19.7    6.0   2717       10    2330    1.450    13.91     155
  4   1200      24.3      6    18.6    6.9   3130       11    2505    1.090    13.91     425
  5   1200      33.8      8    17.3    7.6   3452       25    2243     .440    13.91     845
  6   1200      67.5     15    12.7    9.9   4504       19    1801     .130    13.48    1962
  7   1200     101.2     23     5.0   15.4   6985       16     331     .100    12.94    1825
  8   1200     110.7     25     3.4   16.2   7348       15     499     .130    12.94    2212
  9   1200     124.2     28     2.2   18.5   8380       43     792     .150    13.18    2650
 10   1200     134.0     31     0.0   23.3  10569       35    4049    9.630     8.04     100
 11    700       0.0      0    17.6    4.0   1805       11    1109     .100    11.72      66
 12   1200       0.0      0    21.6    4.0   1823       30   45688     .350     6.73      15
 13   2300     161.0     71      .9   44.0  19958       44    2791    5.080    11.48     830
 14   2300     148.1     65     2.5   36.0  16330       57     979    1.270    13.63    2087
 15   2300     132.0     58     3.5   31.8  14424       18     508     .280    13.63    2550
 16   2300     120.7     53     4.7   29.0  13132       15     332     .210    13.48    2500
 17   2300      80.5     35    10.9   20.7   9412       13     420     .150    12.94    2650
 18   2300      40.2     18    17.2   14.4   6509       11    1507     .180    13.33    2350
 19   2300      29.0     13    18.7   12.5   5670       11    1534     .210    13.63    1700
 20   2300      12.9      6    20.4   10.4   4695       10    1264     .310    13.63     800
 21   2300       3.2      1    21.3    9.1   4128       10    1222     .490    13.77     430
 22    700       0.0      0    17.9    3.7   1656        9     793     .150    12.47      63
 23   2300       0.0      0    25.1    3.8   1737       55   31195     .390     8.60      14
-----------------------------------------------------------------------------------
            CALCULATED GRAM/HR          WT.      WT.   BRAKE  SPECIFIC  GRAM/BHP-HR
MODE  ALDE.     HC       CO     NO2    FAC.      HP    ALDE.      HC       CO     NO2
-----------------------------------------------------------------------------------
  1      .3    16.2      44     3.0   .070      0.0      R        R        R       R
  2      .4    34.5     494     6.4   .060       .0     .7    55.88    801.5    10.4
  3      .4    40.6     510     9.0   .060       .1     .2    16.45    206.8     3.6
  4      .5    51.4     452    29.0   .050       .3     .1     9.26     81.4     5.2
  5     1.3    53.1     211    66.4   .030       .2     .2     6.89     27.3     8.6
  6     1.4    58.8      86   212.8   .060       .9     .1     3.82      5.6    13.8
  7     1.8    17.7     108   323.8  0.000      0.0     .1      .76      4.7    14.0
  8     1.8    27.9     147   411.4   .040      1.0     .1     1.10      5.8    16.3
  9     5.8    49.5     189   549.8  0.000      0.0     .2     1.74      6.7    19.4
 10     4.4   236.7   11374    19.4  0.000      0.0     .1     7.73    371.5      .6
 11      .4    16.8      31     3.3   .070      0.0      R        R        R       R
 12     1.0   715.2     111      .8   .120      0.0      R        R        R       R
 13    11.2   330.8   12162   326.6   .025      1.8     .2     4.69    172.5     4.6
 14    13.4   106.5    2793   754.6   .055      3.6     .2     1.64     43.1    11.6
 15     4.0    52.5     584   874.7   .035      2.0     .1      .91     10.1    15.1
 16     3.0    31.8     406   794.2   .060      3.2     .1      .60      7.7    15.0
 17     2.1    30.1     217   630.6   .060      2.1     .1      .85      6.2    17.9
 18     1.2    71.8     173   371.8  0.000      0.0     .1     4.07      9.8    21.1
 19     1.0    62.2     172   228.7   .065       .8     .1     4.90     13.5    18.0
 20      .7    42.2     209    88.6  0.000      0.0     .1     7.48     37.1    15.7
 21      .6    35.1     284    41.0  0.000      0.0     .4    24.88    201.5    29.1
 22      .3    10.3      40     2.7   .080      0.0      R        R        R       R
 23     1.7   447.5     113      .7   .060      0.0      R        R        R       R

CYCLE COMPOSITE    HC      9.495    GRAM/BHP HR
                   CO     40.711    GRAM/BHP HR
                   NO2    13.358    GRAM/BHP HR
                   ALDE     .130    GRAM/BHP HR
                   BSFC     .750      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-08-72 RUN 3                   ENGINE 2-1          STATIONARY DYNAMOMETER
------------------------------------------------------------------------------------
              DYNA.          MAN.   FUEL  RATE              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  GM/HR    ALDE.     HC       CO      CO2     NO
------------------------------------------------------------------------------------
  1   700      0.0     0   17.6   4.0   1810       0     896     .100    12.82     32
  2  1200      2.7     1   19.8   5.7   2604       0    2357    1.550    14.05     63
  3  1200     10.8     2   19.4   6.0   2717       0    2493    1.480    14.05    165
  4  1200     24.3     6   18.2   6.9   3130       0    2673    1.200    14.18    370
  5  1200     33.8     8   17.2   7.6   3452       0    2477     .440    14.31    730
  6  1200     67.5    15   12.6   9.9   4504       0    2038     .130    14.18   1700
  7  1200    101.2    23    4.9  15.4   6985       0     547     .130    13.77   1650
  8  1200    110.7    25    3.3  16.2   7348       0     575     .130    13.63   1950
  9  1200    124.2    28    2.2  18.5   8380       0     831     .150    13.91   2350
 10  1200    135.0    31    0.0  23.3  10569       0    4055   10.440     8.14     83
 11   700      0.0     0   17.6   4.0   1805       0     696     .130    13.06     68
 12  1200      0.0     0   21.4   4.0   1823       0   41548     .250     4.84     12
 13  2300    161.0    71    1.0  44.0  19958       0    2939    5.960    11.01    555
 14  2300    148.1    65    2.3  36.0  16330       0    1435    1.980    14.05   1862
 15  2300    132.0    58    3.4  31.8  14424       0     817     .580    14.05   2500
 16  2300    120.7    53    4.7  29.0  13132       0     481     .310    14.05   2600
 17  2300     80.5    35   10.7  20.7   9412       0     462     .150    13.48   2950
 18  2300     40.2    18   16.7  14.4   6509       0    1526     .180    13.91   2650
 19  2300     29.0    13   18.2  12.5   5670       0    1232     .180    13.91   1787
 20  2300     12.9     6   20.2  10.4   4695       0    1099     .280    14.05    860
 21  2300      3.2     1   21.2   9.1   4128       0     930     .390    14.05    440
 22   700      0.0     0   17.7   3.7   1656       0     871     .100    12.47     63
 23  2300      0.0     0   24.8   3.8   1737       0   17666     .100     3.35      9
------------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC        CO      NO2  FAC.      HP   ALDE.     HC       CO      NO2
------------------------------------------------------------------------------------
  1   0.0    12.5       28      1.5  .070      0.0      I      R        R        R
  2   0.0    38.8      515      3.4  .060       .0    0.0  62.83    834.5      5.5
  3   0.0    42.9      515      9.4  .060       .1    0.0  17.40    208.6      3.8
  4   0.0    53.5      485     24.6  .050       .3    0.0   9.63     87.3      4.4
  5   0.0    57.0      205     55.8  .030       .2    0.0   7.39     26.5      7.2
  6   0.0    63.3       81    175.2  .060       .9    0.0   4.10      5.3     11.4
  7   0.0    27.4      131    274.2 0.000      0.0    0.0   1.18      5.7     11.9
  8   0.0    30.6      140    344.3  .040      1.0    0.0   1.21      5.5     13.6
  9   0.0    49.2      180    462.3 0.000      0.0    0.0   1.73      6.3     16.3
 10   0.0   225.7    11747     15.2 0.000      0.0    0.0   7.32    380.6       .5
 11   0.0     9.5       36      3.1  .070      0.0      I      R        R        R
 12   0.0   819.5      100       .8  .120      0.0      I      R        R        R
 13   0.0   339.7    13918    213.0  .025      1.8    0.0   4.82    197.4      3.0
 14   0.0   144.9     4038    624.3  .055      3.6    0.0   2.23     62.3      9.6
 15   0.0    80.1     1149    813.8  .035      2.0    0.0   1.39     19.9     14.1
 16   0.0    43.9      571    786.7  .060      3.2    0.0    .83     10.8     14.9
 17   0.0    31.8      209    674.0  .060      2.1    0.0    .90      5.9     19.1
 18   0.0    64.7      166    402.1 0.000      0.0    0.0   3.96      9.4     22.8
 19   0.0    49.2      145    236.7  .065       .8    0.0   3.87     11.4     18.7
 20   0.0    35.7      184     92.8 0.000      0.0    0.0   6.33     32.6     16.5
 21   0.0    26.4      224     41.5 0.000      0.0    0.0  18.72    158.7     29.4
 22   0.0    11.4       26      2.7  .080      0.0      I      R        R        R
 23   0.0   588.3       67       .9  .060      0.0      I      R        R        R

CYCLE COMPOSITE   HC     11.020    GRAM/BHP HR
                  CO     49.177    GRAM/BHF HR
                  NO2    12.413    GRAM/BHP HR
                  ALDE    0.000    GRAM/BHP HR
                  BSFC     .750      LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-09-72 RUN 2                    ENGINE 2-1           STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------
               DYNA.       MAN.   FUEL RATE                DRY CONCENTRATION
MODE SPEED     LOAD   HP  VAC. LB/HR  GM/HR    ALDE.    HC        CO       CO2     NO
-------------------------------------------------------------------------------
   1   700      0.0    0  17.7   4.0   1810        0  1121      .150     12.94     77
   2  1200      2.7    1  20.2   5.7   2604        0  2174     1.300     14.31    116
   3  1200     10.8    2  19.7   6.0   2717        0  2493     1.340     14.18    175
   4  1200     24.3    6  18.5   6.9   3130        0  2718     1.050     14.31    425
   5  1200     33.8    8  17.3   7.6   3452        0  2522      .420     14.31    860
   6  1200     67.5   15  12.7   9.9   4504        0  2104      .150     14.05   1900
   7  1200    101.2   23   5.0  15.4   6985        0   647      .150     13.48   1700
   8  1200    110.7   25   3.4  16.2   7348        0   552      .190     13.48   2075
   9  1200    124.2   28   2.3  18.5   8380        0   773      .150     13.77   2000
  10  1200    135.0   31   0.0  23.3  10569        0  4127    10.290      8.34     94
  11   700      0.0    0  17.7   4.0   1805        0   685      .150     13.18     68
  12  1200      0.0    0  21.6   4.0   1823        0 43866      .390      7.28     16
  13  2300    161.0   71    .9  44.0  19958        0  2934     5.780     11.01    610
  14  2300    148.1   65   2.5  36.0  16330        0  1231     1.590     13.48   2075
  15  2300    132.0   58   3.5  31.8  14424        0   691      .490     13.91   2650
  16  2300    120.7   53   4.7  29.0  13132        0   356      .280     13.91   2650
  17  2300     80.5   35  10.9  20.7   9412        0   416      .180     13.18   3000
  18  2300     40.2   18  17.0  14.4   6509        0  1401      .250     13.77   2700
  19  2300     30.0   13  18.5  12.5   5670        0  1344      .250     13.77   1825
  20  2300     12.9    6  20.2  10.4   4695        0  1152      .210     13.77    820
  21  2300      3.2    1  21.0   9.1   4128        0  1118      .450     13.48    460
  22   700      0.0    0  17.8   3.7   1656        0  1007      .150     12.71     83
  23  2300      0.0    0  25.0   3.8   1737        0 29299      .280      8.75     17
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC        CO     NO2
-------------------------------------------------------------------------------
   1   0.0   15.4       42     3.5  .070     0.0      I       R         R       R
   2   0.0   35.8      432     6.3  .060      .0    0.0   57.98     700.2    10.3
   3   0.0   43.0      466    10.0  .060      .1    0.0   17.41     189.0     4.1
   4   0.0   54.4      425    28.3  .050      .3    0.0    9.80      76.5     5.1
   5   0.0   58.1      195    65.8  .030      .2    0.0    7.54      25.3     8.5
   6   0.0   65.8       95   197.2  .060      .9    0.0    4.26       6.1    12.8
   7   0.0   33.0      155   287.9 0.000     0.0    0.0    1.43       6.7    12.4
   8   0.0   29.6      205   368.8  .040     1.0    0.0    1.17       8.1    14.6
   9   0.0   46.3      181   397.5 0.000     0.0    0.0    1.63       6.4    14.0
  10   0.0  229.0    11536    17.3 0.000     0.0    0.0    7.43     374.0      .6
  11   0.0    9.2       41     3.0  .070     0.0      I       R         R       R
  12   0.0  663.4      119      .8  .120     0.0      I       R         R       R
  13   0.0  342.8    13640   236.6  .025     1.8    0.0    4.86     193.5     3.4
  14   0.0  132.3     3452   740.4  .055     3.6    0.0    2.04      53.2    11.4
  15   0.0   68.4      987   877.1  .035     2.0    0.0    1.19      17.1    15.2
  16   0.0   32.9      522   812.1  .060     3.2    0.0     .62       9.9    15.4
  17   0.0   29.2      255   699.5  .060     2.1    0.0     .83       7.2    19.8
  18   0.0   64.4      232   412.1 0.000     0.0    0.0    3.65      13.2    23.4
  19   0.0   53.9      202   242.7  .065      .9    0.0    4.10      15.4    18.5
  20   0.0   38.4      141    90.7 0.000     0.0    0.0    6.80      25.0    16.1
  21   0.0   32.9      267    44.9 0.000     0.0    0.0   23.30     189.5    31.8
  22   0.0   12.9       39     3.5  .080     0.0      I       R         R       R
  23   0.0  425.6       82      .8  .060     0.0      I       R         R       R

CYCLE COMPOSITE     HC       9.159    GRAM/BHP HR
                    CO      46.396    GRAM/BHP HR
                    NO2     13.372    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .748      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-10-72 RUN 1                      ENGINE 2-1            STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------
                 DYNA.           MAN.    FUEL  RATE                 DRY CONCENTRATION
MODE  SPEED      LOAD     HP    VAC.  LB/HR   GM/HR    ALDE.     HC       CO       CO2      NO
-----------------------------------------------------------------------------------
  1    700        0.0      0    17.6    4.0    1810      17     626     .100    12.71      30
  2   1200        2.7      1    20.1    5.7    2604      16    2208    1.550    14.05      59
  3   1200       10.8      2    19.7    6.0    2717      14    2563    1.520    14.05      83
  4   1200       24.3      6    18.5    6.9    3130      14    2784    1.200    14.05     206
  5   1200       33.8      8    17.3    7.6    3452      26    2612     .490    14.18     710
  6   1200       67.5     15    12.6    9.9    4504      19    2147     .150    13.91    1675
  7   1200      101.2     23     4.8   15.4    6985      16     444     .150    13.33    1550
  8   1200      110.7     25     3.2   16.2    7348      17     563     .150    13.48    1950
  9   1200      124.2     28     2.2   18.5    8380      44     971     .180    13.77    2350
 10   1200      135.0     31     0.0   23.3   10569      36    4022   10.140     8.14      82
 11    700        0.0      0    17.6    4.0    1805      13     891     .130    12.22      61
 12   1200        0.0      0    21.4    4.0    1823      26   45252     .150     7.56      11
 13   2300      161.0     71      .9   44.0   19958      36    3030    5.900    11.01     525
 14   2300      148.1     65     2.2   36.0   16330      51    1246    1.660    13.77    1825
 15   2300      132.0     58     3.4   31.8   14424      19     533     .420    14.05    2300
 16   2300      120.7     53     4.4   29.0   13132      16     277     .210    13.91    2250
 17   2300       80.5     35    10.6   20.7    9412      11     360     .180    13.18    2250
 18   2300       40.2     18    17.0   14.4    6509      24    1558     .210    13.77    2250
 19   2300       29.0     13    18.4   12.5    5670      23    1356     .250    13.77    1563
 20   2300       12.9      6    20.2   10.4    4695      26    1099     .280    14.05     820
 21   2300        3.2      1    21.2    9.1    4128      18    1066     .420    14.05     420
 22    700        0.0      0    17.7    3.7    1656      11     862     .150    12.71      57
 23   2300        0.0      0    25.0    3.8    1737      52   28534     .420     9.03      17
-----------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.   BRAKE  SPECIFIC  GRAM/BHP-HR
MODE ALDE.      HC        CO     NO2   FAC.      HP   ALDE.      HC       CO      NO2
-----------------------------------------------------------------------------------
  1     .5     8.8        28     1.4   .070     0.0      R        R        R        R
  2     .6    36.3       515     3.2   .060      .0     .9    58.92    835.3      5.2
  3     .5    44.0       527     4.7   .060      .1     .2    17.83    213.6      1.9
  4     .6    56.1       489    13.8   .050      .3     .1    10.11     88.0      2.5
  5    1.3    60.4       229    54.5   .030      .2     .2     7.83     29.7      7.1
  6    1.3    67.7        96   175.5   .060      .9     .1     4.39      6.2     11.4
  7    1.8    22.9       157   265.8  0.000     0.0     .1      .99      6.8     11.5
  8    2.0    30.2       163   347.6   .040     1.0     .1     1.20      6.4     13.7
  9    5.7    57.9       217   465.5  0.000     0.0     .2     2.04      7.6     16.4
 10    4.4   227.5     11588    15.4  0.000     0.0     .1     7.38    375.7       .5
 11     .4    12.9        38     2.9   .070     0.0      R        R        R        R
 12     .8   674.4        45      .5   .120     0.0      R        R        R        R
 13    9.0   351.3     13819   202.1   .025     1.8     .1     4.98    196.0      2.9
 14   11.7   130.8      3520   636.1   .055     3.6     .2     2.02     54.3      9.8
 15    4.1    52.9       843   758.4   .035     2.0     .1      .92     14.6     13.1
 16    3.2    25.7       394   693.4   .060     3.2     .1      .49      7.4     13.1
 17    1.7    25.3       255   524.9   .060     2.1     .0      .72      7.2     14.9
 18    2.4    71.8       195   344.0  0.000     0.0     .1     4.07     11.1     19.5
 19    2.0    54.3       202   207.8   .065      .8     .2     4.28     15.9     16.4
 20    1.8    35.7       184    88.5  0.000     0.0     .3     6.33     32.6     15.7
 21    1.1    30.2       240    39.5  0.000     0.0     .8    21.40    170.4     28.0
 22     .3    11.0        39     2.4   .080     0.0      R        R        R        R
 23    1.6   402.9       120      .8   .060     0.0      R        R        R        R

CYCLE COMPOSITE   HC       9.109   GRAM/BHP HR
                  CO      46.411   GRAM/BHP HR
                  NO2     11.245   GRAM/BHP HR
                  ALDE      .125   GRAM/BHP HR
                  BSFC      .750     LB/BHP HR
```

PROJECT 11-2877-01 CONTROL TECHNOLOGY

3-13-72 RUN 1 ENGINE 2-1 STATIONARY DYNAMOMETER

MODE	SPEED	DYNA. LOAD	HP	MAN. VAC.	FUEL LB/HR	RATE GM/HR	ALDE.	DRY CONCENTRATION HC	CO	CO2	NO
1	700	0.0	0	17.8	4.0	1810	0	739	.070	12.94	50
2	1200	2.7	1	20.0	5.7	2604	0	2672	1.590	13.77	104
3	1200	10.8	2	19.4	6.0	2717	0	2831	1.550	13.77	144
4	1200	24.3	6	18.3	6.9	3130	0	3050	1.160	13.77	310
5	1200	33.8	8	17.3	7.6	3452	0	2401	.470	13.91	660
6	1200	67.5	15	12.5	9.9	4504	0	2324	.100	13.77	1600
7	1200	101.2	23	4.8	15.4	6985	0	573	.070	13.18	1525
8	1200	110.7	25	3.1	16.2	7348	0	494	.070	13.18	1700
9	1200	124.2	28	1.9	18.5	8380	0	707	.100	13.18	2175
10	1200	135.0	31	0.0	23.3	10569	0	3633	9.170	8.60	109
11	700	0.0	0	17.9	4.0	1805	0	593	.070	12.71	63
12	1200	0.0	0	21.6	4.0	1823	0	40915	.350	6.73	13
13	2300	161.0	71	.9	44.0	19958	0	3018	5.290	11.13	540
14	2300	148.1	65	2.1	36.0	16330	0	1588	2.050	13.33	1575
15	2300	132.0	58	3.2	31.8	14424	0	702	.470	13.91	2100
16	2300	120.7	53	4.2	29.0	13132	0	373	.210	13.77	2050
17	2300	80.5	35	10.2	20.7	9412	0	337	.150	13.18	2000
18	2300	40.2	18	16.9	14.4	6509	0	1535	.180	13.77	2100
19	2300	29.0	13	18.3	12.5	5670	0	1513	.210	13.77	1362
20	2300	12.9	6	20.2	10.4	4695	0	1233	.310	13.91	660
21	2300	3.2	1	21.2	9.1	4128	0	1224	.470	13.91	490
22	700	0.0	0	17.8	3.7	1656	0	851	.100	12.82	63
23	2300	0.0	0	24.9	3.8	1737	0	30541	.390	8.75	16

MODE	CALCULATED GRAM/HR ALDE.	HC	CO	NO2	WT. FAC.	WT. HP	BRAKE SPECIFIC GRAM/BHP-HR ALDE.	HC	CO	NO2
1	0.0	10.2	20	2.3	.070	0.0	I	R	R	R
2	0.0	44.5	535	5.7	.060	.0	0.0	72.18	867.4	9.3
3	0.0	49.3	545	8.3	.060	.1	0.0	19.98	220.9	3.4
4	0.0	62.7	481	21.1	.050	.3	0.0	11.29	86.7	3.8
5	0.0	68.2	223	51.6	.030	.2	0.0	8.85	29.0	6.7
6	0.0	74.2	65	169.7	.060	.9	0.0	4.81	4.2	11.0
7	0.0	30.1	74	265.8	0.000	0.0	0.0	1.30	3.2	11.5
8	0.0	27.3	78	311.8	.040	1.0	0.0	1.08	3.1	12.3
9	0.0	44.4	127	453.3	0.000	0.0	0.0	1.56	4.5	16.0
10	0.0	211.7	10796	21.0	0.000	0.0	0.0	6.86	350.0	.7
11	0.0	8.3	20	2.9	.070	0.0	I	R	R	R
12	0.0	667.8	115	.7	.120	0.0	I	R	R	R
13	0.0	360.2	12754	214.0	.025	1.8	0.0	5.11	180.9	3.0
14	0.0	166.9	4352	549.5	.055	3.6	0.0	2.57	67.1	8.5
15	0.0	70.1	948	696.0	.035	2.0	0.0	1.21	16.4	12.0
16	0.0	34.9	397	637.6	.060	3.2	0.0	.66	7.5	12.1
17	0.0	23.7	213	467.7	.060	2.1	0.0	.67	6.1	13.3
18	0.0	70.9	168	321.8	0.000	0.0	0.0	4.02	9.5	18.3
19	0.0	60.7	170	181.4	.065	.8	0.0	4.78	13.4	14.3
20	0.0	40.4	205	71.7	0.000	0.0	0.0	7.16	36.3	12.7
21	0.0	34.8	270	46.3	0.000	0.0	0.0	24.70	191.6	32.8
22	0.0	10.8	26	2.7	.080	0.0	I	R	R	R
23	0.0	435.1	112	.7	.060	0.0	I	R	R	R

CYCLE COMPOSITE HC 9.496 GRAM/BHP HR
CO 47.650 GRAM/BHP HR
NO2 10.240 GRAM/BHP HR
ALDE 0.000 GRAM/BHP HR
BSFC .750 LB/BHP HR

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-13-72 RUN 2                  ENGINE 2-1           STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------
              DYNA.        MAN.   FUEL  RATE                DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  GM/HR    ALDE.    HC       CO       CO2     NO
--------------------------------------------------------------------------------
  1    700     0.0     0  17.3   4.0   1810         0    817    .050    12.82     51
  2   1200     2.7     1  19.8   5.7   2604         0   2375   1.300    14.05    106
  3   1200    10.8     2  19.3   6.0   2717         0   2652   1.410    14.05    141
  4   1200    24.3     6  18.2   6.9   3130         0   2943   1.160    14.05    310
  5   1200    33.8     8  17.2   7.6   3452         0   2838    .440    14.18    660
  6   1200    67.5    15  12.3   9.9   4504         0   2213    .070    13.91   1537
  7   1200   101.2    23   4.7  15.4   6985         0    585    .100    13.33   1425
  8   1200   110.7    25   3.1  16.2   7348         0    563    .100    13.48   1725
  9   1200   124.2    28   2.0  18.5   8380         0    879    .070    13.63   2100
 10   1200   135.0    31   0.0  23.3  10569         0   4421   9.910     8.43     93
 11    700     0.0     0  17.7   4.0   1805         0    832    .050    13.33     65
 12   1200     0.0     0  21.7   4.0   1823         0  46523    .280     7.18     17
 13   2300   161.0    71    .9  44.0  19958         0   3220   5.560    10.66    575
 14   2300   148.1    65   2.2  36.0  16330         0   1729   2.140    12.71   1600
 15   2300   132.0    58   3.3  31.8  14424         0    882    .610    13.48   2150
 16   2300   120.7    53   4.3  29.0  13132         0    446    .350    13.48   2200
 17   2300    80.5    35  10.2  20.7   9412         0    303    .210    12.82   2150
 18   2300    40.2    18  16.7  14.4   6509         0   1732    .280    13.18   2200
 19   2300    29.0    13  18.2  12.5   5670         0   1531    .280    13.33   1500
 20   2300    12.9     6  20.1  10.4   4695         0   1354    .420    13.48    720
 21   2300     3.2     1  21.1   9.1   4128         0   1288    .520    13.48    390
 22    700     0.0     0  17.7   3.7   1656         0    893    .100    12.47     60
 23   2300     0.0     0  24.9   3.8   1737         0  29066    .250     8.54     15
--------------------------------------------------------------------------------
            CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.     HC      CO     NO2
--------------------------------------------------------------------------------
  1    0.0    11.4      14     2.4  .070     0.0      I      R       R       R
  2    0.0    39.7     439     5.9  .060       0    0.0  64.31   711.0     9.6
  3    0.0    45.8     492     8.1  .060      .1    0.0  18.57   199.4     3.3
  4    0.0    59.4     473    20.8  .050      .3    0.0  10.70    85.2     3.7
  5    0.0    65.7     206    50.8  .030      .2    0.0   8.52    26.7     6.6
  6    0.0    70.2      45   161.9  .060      .9    0.0   4.55     2.9    10.5
  7    0.0    30.3     105   245.0 0.000     0.0    0.0   1.31     4.5    10.6
  8    0.0    30.3     109   308.6  .040     1.0    0.0   1.20     4.3    12.2
  9    0.0    53.4      86   423.8 0.000     0.0    0.0   1.88     3.0    14.9
 10    0.0   248.8   11264    17.3 0.000     0.0    0.0   8.07   365.2      .6
 11    0.0    11.2      14     2.9  .070     0.0      I      R       R       R
 12    0.0   200.4      85      .8  .120     0.0      I      R       R       R
 13    0.0   388.5   13551   230.3  .025     1.8    0.0   5.51   192.2     3.3
 14    0.0   187.9    4699   577.4  .055     3.6    0.0   2.90    72.4     8.9
 15    0.0    89.7    1254   726.2  .035     2.0    0.0   1.55    21.7    12.6
 16    0.0    42.2     669   691.3  .060     3.2    0.0    .80    12.7    13.1
 17    0.0    21.8     306   514.4  .060     2.1    0.0    .62     8.7    14.6
 18    0.0    82.7     220   348.7 0.000     0.0    0.0   4.69    15.3    19.8
 19    0.0    63.1     233   205.2  .065      .8    0.0   4.97    18.4    16.2
 20    0.0    45.3     284    80.0 0.000     0.0    0.0   8.03    50.3    14.2
 21    0.0    37.6     307    37.8 0.000     0.0    0.0  26.68   217.6    26.8
 22    0.0    11.7      26     2.6  .080     0.0      I      R       R       R
 23    0.0   431.7      75      .7  .060     0.0      I      R       R       R

CYCLE COMPOSITE     HC       9.883    GRAM/BHP HR
                    CO      51.324    GRAM/BHP HR
                    NO2     10.858    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .750      LB/BHP HR
```

APPENDIX B

EMISSION RESULTS FROM ENGINE 1-1

TABULAR FORM

ENGINE 1-1

NINE MODE FTP EMISSION RESULTS

CONCENTRATION BASIS

```
           3-21-72          ENGINE 1-1          RUN 1                                    K = .941     HUM =  60  GR/LB
           ---------------------------------------------------------------------------------------------------------------
           FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION    A D J U S T E D   WEIGHTING        W E I G H T E D
           MODE             HC     CO    CO2     NO      FACTOR     HC    CO    NO     FACTOR         HC       CO       NO
           ---------------------------------------------------------------------------------------------------------------
CYCLE 1
           1 IDLE          167   .994  14.320     78      .967     161   .961     75    .036         5.813    .035     2.715
           2 16'HG          58   .139  13.170   2006     1.090      63   .152   2187    .089         5.627    .013   194.611
           3 10'HG          39   .136  12.680   2264     1.134      44   .154   2567    .257        11.363    .040   659.634
           4 16'HG          61   .146  13.260   1710     1.082      66   .158   1851    .089         5.875    .014   164.647
           5 19'HG          36   .147  13.440   1795     1.070      39   .157   1921    .047         1.810    .007    90.264
           6 16'HG          24   .143  13.220   2238     1.089      26   .156   2437    .089         2.326    .014   216.869
           7  3'HG          47   .808  13.330   2055     1.052      49   .850   2162    .283        13.991    .241   611.740
           8 16'HG          40   .165  13.290   1730     1.081      43   .178   1870    .089         3.848    .016   166.414
           9 C.T.         2402   .866   7.480     71     1.380    3315  1.195     98    .021        69.611    .025     2.058
           SUM------------(CYCLE COMPOSITE)---------------------------------------------------     120.263    .405  2109.002
CYCLE 2
           1 IDLE          167   .994  14.320     78      .967     161   .961     75    .036         5.813    .035     2.715
           2 16'HG          40   .144  13.110   1787     1.096      44   .158   1959    .089         3.903    .014   174.373
           3 10'HG          39   .136  12.650   2384     1.136      44   .155   2709    .257        11.390    .040   696.230
           4 16'HG          35   .147  13.140   1866     1.094      38   .161   2042    .089         3.409    .014   181.724
           5 19'HG          42   .169  14.210   1228     1.011      42   .171   1242    .047         1.946    .008    58.361
           6 16'HG          32   .145  13.340   1938     1.078      34   .156   2088    .089         3.069    .014   185.850
           7  3'HG          39   .678  13.300   1394     1.060      41   .719   1477    .283        11.698    .203   418.115
           8 16'HG          28   .158  13.230   1995     1.087      30   .172   2169    .089         2.709    .015   193.006
           9 C.T.         2332  1.010   8.010     98     1.314    3065  1.327    129    .021        64.358    .028     2.705
           SUM------------(CYCLE COMPOSITE)---------------------------------------------------     108.343    .371  1913.077
CYCLE 3
           1 IDLE          144  1.218  14.140     86      .973     140  1.185     84    .036         5.043    .043     3.012
           2 16'HG          49   .147  13.100   1741     1.096      54   .161   1909    .089         4.781    .014   169.869
           3 10'HG          37   .141  12.680   2509     1.134      42   .160   2844    .257        10.780    .041   730.997
           4 16'HG          33   .148  13.240   2025     1.086      36   .161   2199    .089         3.190    .014   195.755
           5 19'HG          42   .186  14.210   1327     1.011      42   .188   1341    .047         1.995    .009    63.028
           6 16'HG          38   .154  13.220   2114     1.087      41   .167   2298    .089         3.677    .015   204.537
           7  3'HG          39   .759  13.300   1554     1.057      41   .802   1642    .283        11.663    .227   464.729
           8 16'HG          27   .163  13.260   2015     1.084      29   .177   2185    .089         2.606    .016   194.482
           9 C.T.         2302   .911   7.580     79     1.378    3172  1.255    109    .021        66.621    .026     2.286
           SUM------------(CYCLE COMPOSITE)---------------------------------------------------     110.355    .405  2028.696
CYCLE 4
           1 IDLE          144  1.218  14.140     86      .973     140  1.185     84    .036         5.043    .043     3.012
           2 16'HG          47   .151  13.070   1795     1.099      52   .166   1972    .089         4.596    .015   175.538
           3 10'HG          36   .142  12.620   2450     1.139      41   .162   2791    .257        10.539    .042   717.204
           4 16'HG          36   .148  13.100   1976     1.097      40   .162   2168    .089         3.516    .014   192.996
           5 19'HG          45   .193  14.170   1263     1.013      46   .195   1279    .047         2.142    .009    60.128
           6 16'HG          39   .149  13.070   2086     1.100      43   .164   2294    .089         3.817    .015   204.145
           7  3'HG          40   .683  13.150   1516     1.071      43   .732   1624    .283        12.127    .207   459.626
           8 16'HG          30   .166  13.110   2118     1.096      33   .182   2322    .089         2.927    .016   206.669
           9 C.T.         2352   .924   7.920     94     1.327    3122  1.232    125    .021        65.560    .026     2.620
           SUM------------(CYCLE COMPOSITE)---------------------------------------------------     110.268    .386  2021.938

           AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------     114.303    .388  2011.039

           AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------     110.311    .396  2025.317

           FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*( 114.303) + 0.65*( 110.311) =  111.708  PPM
                                                       CO    0.35*(    .388) + 0.65*(    .396) =     .393  PERCENT
                                                       NO    0.35*( 2011.039) + 0.65*( 2025.317) = 2020.320  PPM
                                                                                 CORRECTED NO = 1901.606  PPM

           DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
3-21-72          ENGINE J-1          RUN 2                                      K = .429      HUM =  57  GR/LB
------------------------------------------------------------------------------------------------------------------
FEDERAL          CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D    WEIGHTING          W E I G H T E D
MODE                HC      CO     CO2    NO     FACTOR      HC      CO    NO      FACTOR          HC      CO       NO
------------------------------------------------------------------------------------------------------------------
CYCLE 1
          1 IDLE      114    .856  15.290     80     .915       104    .784     73      .036         3.757   .028     2.636
          2 16'HG      48    .161  13.420   1963    1.028        49    .166   2018      .089         4.342   .015   179.633
          3 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  40  [illegible]  2796  .257  10.210  .041  718.536
          4 16'HG      34    .166  14.150   2282    1.016        35    .169   2319      .089         3.075   .015   206.376
          5 19'HG      36    .171  15.050   1411     .956        34    .163   1348      .047         1.617   .008    63.370
          6 16'HG      37    .166  14.200   2256    1.012        37    .168   2284      .089         3.334   .015   203.266
          7  3'HG      38    .880  14.320   1639     .980        37    .862   1606      .283        10.535   .244   454.403
          8 16'HG      29    .174  14.290   2447    1.006        29    .175   2463      .089         2.547   .016   219.169
          9 C.T.     2071    .780   8.130    196    1.348      2792   1.051    264      .021        58.626   .022     5.548
          SUM------------(CYCLE COMPOSITE)--------------------------------------------------        98.143   .404  2052.937
CYCLE 2
          1 IDLE      114    .856  15.290     80     .915       104    .784     73      .036         3.757   .028     2.636
          2 16'HG      53    .161  14.180   2021    1.013        54    .163   2047      .089         4.777   .015   182.159
          3 10'HG      38    .145  13.720   2814    1.048        40    .152   2950      .257        10.236   .039   758.040
          4 16'HG      38    .161  14.350   2267    1.002        38    .161   2271      .089         3.389   .014   202.160
          5 19'HG      38    .180  15.200   1375     .946        36    .170   1300      .047         1.689   .008    61.122
          6 16'HG      36    .159  14.320   2414    1.004        36    .160   2424      .089         3.218   .014   215.763
          7  3'HG      34    .922  14.410   1860     .973        33    .897   1809      .283         9.359   .254   511.984
          8 16'HG      34    .169  14.380   2514    1.000        34    .169   2514      .089         3.026   .015   223.727
          9 C.T.     2143    .876   8.410    102    1.299      2784   1.138    132      .021        58.459   .024     2.782
          SUM------------(CYCLE COMPOSITE)--------------------------------------------------        97.909   .411  2160.372
CYCLE 3
          1 IDLE      161    .808  15.550     77     .899       145    .726     69      .036         5.211   .026     2.492
          2 16'HG      52    .155  14.280   2139    1.006        52    .156   2152      .089         4.656   .014   191.511
          3 10'HG  [illegible]  .147  13.930  [illegible]  [illegible]  [illegible]  .153  3032  .257   9.622   .039   779.117
          4 16'HG      32    .165  14.340   2346    1.003        32    .165   2353      .089         2.856   .015   209.414
          5 19'HG      45    .194  15.310   1448     .938        42    .182   1358      .047         1.984   .009    63.848
          6 16'HG      35    .166  14.330   2345    1.003        35    .167   2353      .089         3.126   .015   209.416
          7  3'HG      32    .868  14.470   1830     .971        31    .843   1776      .283         8.790   .238   502.686
          8 16'HG      35    .170  14.640   2671     .982        34    .167   2623      .089         3.060   .015   233.487
          9 C.T.     2124    .847   8.300     81    1.316      2795   1.115    107      .021        58.703   .023     2.239
          SUM------------(CYCLE COMPOSITE)--------------------------------------------------        98.008   .344  2194.211
CYCLE 4
          1 IDLE      161    .608  15.550     77     .899       145    .726     69      .036         5.211   .026     2.492
          2 16'HG      48    .165  14.230   1920    1.009        48    .167   1938      .089         4.312   .015   172.494
          3 10'HG      40    .146  13.730   2810    1.047        42    .153   2943      .257        10.765   .039   756.270
          4 16'HG      31    .168  14.250   2224    1.009        31    .170   2245      .089         2.784   .015   199.762
          5 19'HG      44    .187  15.190   1371     .946        42    .177   1297      .047         1.956   .008    60.944
          6 16'HG      37    .166  14.270   2246    1.007        37    .167   2263      .089         3.317   .015   201.381
          7  3'HG      40    .816  14.410   1783     .976        39    .796   1740      .283        11.045   .225   492.325
          8 16'HG      32    .171  14.340   2337    1.003        32    .171   2343      .084         2.856   .015   208.567
          9 C.T.     2219    .888   8.610    114    1.267      2812   1.100    144      .021        59.061   .023     3.034
          SUM------------(CYCLE COMPOSITE)--------------------------------------------------       101.308   .382  2097.269

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------        98.026   .407  2106.655

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------        99.658   .388  2145.740

          FOUR CYCLE COMPOSITE - REPORTED VALUES -     HC    0.35*(   98.026) + 0.65*(   99.658) =     99.087  PPM
                                                      CO    0.35*(     .407) + 0.65*(     .388) =       .395  PERCENT
                                                      NO    0.35*( 2106.655) + 0.65*( 2145.740) =   2132.060  PPM
                                                                                   CORRECTED NO =   1979.719  PPM

          DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
3-21-72          ENGINE 1-1          RUN 3                                 K = .981     HUM =  70  GR/LB
------------------------------------------------------------------------------------------------------------------
FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D    WEIGHTING       W E I G H T E D
MODE            HC      CO     CO2    NO     FACTOR    HC     CO    NO     FACTOR        HC       CO      NO
------------------------------------------------------------------------------------------------------------------
CYCLE 1
        1 IDLE        133   .920  13.840     81   1.004    134   .924    81    .036       4.807   .033     2.927
        2 16'HG        38   .149  12.590   2030   1.141     43   .170  2317    .089       3.860   .015   206.187
        3 10'HG        46   .141  12.140   3114   1.178     54   .166  3668    .257      13.925   .043   942.661
        4 16'HG        41   .150  12.710   2602   1.130     46   .170  2941    .084       4.124   .015   261.736
        5 19'HG        35   .160  13.360   1633   1.076     38   .172  1757    .047       1.770   .008    82.572
        6 16'HG        37   .149  12.670   2626   1.134     42   .169  2978    .084       3.735   .015   265.076
        7  3'HG        25   .915  12.670   1651   1.102     28  1.009  1820    .283       7.799   .285   515.024
        8 16'HG        23   .165  12.680   2800   1.134     26   .188  3175    .089       2.321   .017   282.565
        9 C.T.       2100   .772   7.510    279   1.427   2496  1.101   398    .021      62.913   .023     8.358
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------   105.253   .455  2567.106
CYCLE 2
        1 IDLE        133   .920  13.840     81   1.004    134   .924    81    .036       4.807   .033     2.927
        2 16'HG        54   .148  12.590   2352   1.140     62   .169  2681    .089       5.478   .015   238.577
        3 10'HG        37   .140  12.150   3231   1.183     44   .166  3821    .257      11.246   .043   982.085
        4 16'HG        39   .152  12.590   2532   1.141     44   .173  2889    .089       3.960   .015   257.123
        5 19'HG        35   .160  13.370   1713   1.075     38   .172  1842    .047       1.768   .008    86.553
        6 16'HG        36   .149  12.610   2661   1.140     41   .170  3033    .089       3.651   .015   269.898
        7  3'HG        43  1.118  12.690   1698   1.091     47  1.219  1852    .283      13.272   .345   524.070
        8 16'HG        31   .167  12.620   2805   1.138     35   .190  3193    .084       3.141   .017   284.200
        9 C.T.       2469   .198   7.480    146   1.415   3494   .280   207    .021      73.379   .006     4.339
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------   120.703   .497  2649.773
CYCLE 3
        1 IDLE        102  1.081  13.560    115   1.020    104  1.103   117    .036       3.747   .040     4.224
        2 16'HG        28   .150  12.510   2375   1.149     32   .172  2730    .089       2.864   .015   242.955
        3 10'HG        39   .143  12.060   3273   1.191     46   .170  3898    .257      11.938   .044  1001.907
        4 16'HG        21   .150  12.500   2580   1.151     24   .173  2970    .089       2.151   .015   264.294
        5 19'HG        19   .154  13.340   1648   1.079     21   .166  1778    .047        .964   .008    83.580
        6 16'HG        38   .149  12.490   2623   1.150     44   .171  3017    .089       3.890   .015   268.531
        7  3'HG        43  1.112  12.620   1713   1.097     47  1.219  1879    .283      13.345   .345   531.619
        8 16'HG        17   .163  12.580   2937   1.144     19   .186  3359    .089       1.730   .017   298.915
        9 C.T.       2268   .865   7.630    154   1.379   3128  1.193   212    .021      65.697   .025     4.461
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------   106.327   .524  2700.486
CYCLE 4
        1 IDLE        102  1.081  13.560    115   1.020    104  1.103   117    .036       3.747   .040     4.224
        2 16'HG        34   .150  12.520   2486   1.148     39   .172  2854    .089       3.474   .015   253.978
        3 10'HG        23   .143  11.920   3165   1.207     28   .173  3819    .257       7.133   .044   981.528
        4 16'HG        20   .149  12.570   2797   1.145     23   .171  3202    .089       2.038   .015   284.976
        5 19'HG        22   .169  13.420   1647   1.080     24   .182  1778    .047       1.117   .009    83.587
        6 16'HG        23   .152  12.540   3069   1.147     26   .174  3520    .089       2.348   .016   313.313
        7  3'HG        36  1.200  12.640   1775   1.092     39  1.310  1938    .283      11.125   .371   548.519
        8 16'HG        23   .168  12.580   2921   1.143     26   .192  3338    .089       2.339   .017   297.076
        9 C.T.       2147   .821   7.440    149   1.426   3061  1.171   212    .021      64.288   .025     4.462
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------    97.607   .551  2771.663

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------   112.978   .476  2608.440

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------   101.967   .538  2736.075

        FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  112.978) + 0.65*(  101.967) =   105.821  PPM
                                                    CO    0.35*(     .476) + 0.65*(     .538) =      .516  PERCENT
                                                    NO    0.35*( 2608.440) + 0.65*( 2736.075) =  2691.402  PPM
                                                                               CORRECTED NO =  2640.965  PPM

        DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

ENGINE 1-1

NINE MODE FTP EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
3-21-72        ENGINE 1-1        RUN 1                          K =  .95     HUM =  60  GR/LB
---------------------------------------------------------------------------------------------------------
MASS        CONCENTRATION AS MEASURED     TOTAL    FUEL     ADJUSTED (MASS)       WT.      WEIGHTED (MASS)
MODE         HC     CO     CO2     NO     CARBON   CONS.    HC      CO    NO2    FACT.     HC     CO  NO2(K)  HP
---------------------------------------------------------------------------------------------------------

CYCLE 1
        1 IDLE      167   .994  14.32      78   15.494    1634     19     212      3   .232     4.4     49      .6   0
        2 16 HG      58   .139  13.17    2006   13.372    7150     33     150    356   .077     2.6     12    27.4  20
        3 10 HG      39   .136  12.68    2264   12.858   10451     34     223    611   .147     5.0     33    89.8  43
        4 16 HG      61   .146  13.26    1710   13.472    7150     35     157    301   .077     2.7     12    23.2  20
        5 19 HG      36   .147  13.44    1795   13.626    5509     16     120    241   .057      .9      7    13.7  11
        6 16 HG      24   .143  13.22    2238   13.389    7150     14     154    397   .077     1.1     12    30.6  20
        7  3 HG      47   .808  13.33    2055   14.189   14303     51    1645    688   .113     5.8    186    77.7  66
        8 16 HG      40   .165  13.29    1730   13.498    7150     23     177    304   .077     1.8     14    23.4  20
        9 C.T.     2402   .866   7.48      71   10.940    1401    332     224      3   .143    47.5     32      .4   0
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------     3.5     17    13.9

CYCLE 2
        1 IDLE      167   .994  14.32      78   15.494    1634     19     212      3   .232     4.4     49      .6   0
        2 16 HG      40   .144  13.11    1787   13.297    7150     23     156    319   .077     1.8     12    24.6  20
        3 10 HG      39   .136  12.65    2384   12.828   10451     34     224    645   .147     5.0     33    94.8  43
        4 16 HG      35   .147  13.14    1866   13.325    7150     20     159    332   .077     1.6     12    25.6  20
        5 19 HG      42   .169  14.21    1228   14.424    5509     17     130    156   .057     1.0      7     8.9  11
        6 16 HG      32   .145  13.35    1938   13.530    7150     19     155    340   .077     1.4     12    26.2  20
        7  3 HG      39   .678  13.30    1394   14.020   14303     43    1397    472   .113     4.9    158    53.4  66
        8 16 HG      28   .158  13.23    1995   13.418    7150     16     170    353   .077     1.2     13    27.2  20
        9 C.T.     2332  1.010   8.01      98   11.539    1401    306     248      4   .143    43.7     35      .6   0
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------     3.1     16    12.7

CYCLE 3
        1 IDLE      144  1.218  14.14      86   15.514    1634     16     259      3   .232     3.8     60      .7   0
        2 16 HG      49   .147  13.10    1741   13.300    7150     28     160    311   .077     2.2     12    23.9  20
        3 10 HG      37   .141  12.68    2509   12.861   10451     32     231    677   .147     4.8     34    99.5  43
        4 16 HG      33   .148  13.24    2025   13.424    7150     19     159    358   .077     1.5     12    27.6  20
        5 19 HG      42   .186  14.21    1327   14.441    5509     17     143    168   .057     1.0      8     9.6  11
        6 16 HG      38   .154  13.22    2114   13.415    7150     22     166    374   .077     1.7     13    28.8  20
        7  3 HG      39   .759  13.30    1554   14.101   14303     43    1555    523   .113     4.8    176    59.1  66
        8 16 HG      27   .163  13.26    2015   13.452    7150     16     175    356   .077     1.2     13    27.4  20
        9 C.T.     2302   .911   7.58      79   10.977    1401    317     235      3   .143    45.4     34      .5   0
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------     3.2     18    13.4

CYCLE 4
        1 IDLE      144  1.219  14.14      86   15.514    1634     16     259      3   .232     3.8     60      .7   0
        2 16 HG      47   .151  13.07    1795   13.272    7150     27     164    321   .077     2.1     13    24.7  20
        3 10 HG      36   .142  12.62    2450   12.801   10451     32     234    664   .147     4.7     34    97.6  43
        4 16 HG      36   .148  13.10    1976   13.287    7150     21     161    353   .077     1.6     12    27.2  20
        5 19 HG      45   .193  14.17    1263   14.412    5509     19     149    160   .057     1.1      8     9.1  11
        6 16 HG      39   .149  13.07    2086   13.261    7150     23     162    373   .077     1.7     12    28.8  20
        7  3 HG      40   .683  13.15    1516   13.876   14303     45    1422    519   .113     5.0    161    58.6  66
        8 16 HG      30   .166  13.11    2119   13.308    7150     17     180    378   .077     1.3     14    29.1  20
        9 C.T.     2352   .928   7.92      94   11.388    1401    313     231      4   .143    44.7     33      .5   0
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------     3.2     17    13.4

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------------     3.3     17    13.3

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------     3.2     17    13.4

        FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(    3.3) + 0.65(    3.2) =    3.237  (MASS)
                                                 CO  0.35(     17) + 0.65(     17) =     17.0  (MASS)
                                                 NO2 0.35(   13.3) + 0.65(   13.4) =   13.336  (MASS)
                                                                 CORRECTED NO2 =   12.622  (MASS)
```

```
3-21-72         ENGINE 1-1          RUN 2                                   K =  .93     HUM =  57  GR/LB
-------------------------------------------------------------------------------------------------------------
MASS        CONCENTRATION AS MEASURED     TOTAL    FUEL      ADJUSTED (MASS)       WT.       WEIGHTED (MASS)
MODE          HC      CO      CO2     NO   CARBON   CONS.      HC      CO    NO2   FACT.      HC     CO   NO2(K)  HP
-------------------------------------------------------------------------------------------------------------

CYCLE 1
      1 IDLE     114    .856   15.29     80   16.269    1634      12     174     3   .232      2.9     40      .6    0
      2 16 HG     48    .161   13.97   1963   14.193    7150      26     164   329   .077      2.0     13    25.3   20
      3 10 HG     37    .150   13.39   2604   13.580   10451      31     233   665   .147      4.5     34    97.8   43
      4 16 HG     34    .166   14.15   2282   14.353    7150      18     167   377   .077      1.4     13    29.1   20
      5 19 HG     36    .171   15.05   1411   15.260    5509      14     125   169   .057       .8      7     9.6   11
      6 16 HG     37    .166   14.20   2256   14.406    7150      20     166   372   .077      1.5     13    28.6   20
      7  3 HG     38    .980   14.32   1639   15.241   14303      39    1668   511   .113      4.4    189    57.7   66
      8 16 HG     29    .174   14.29   2447   14.495    7150      15     173   401   .077      1.2     13    30.9   20
      9 C.T.    2071    .780    8.13    196   11.147    1401     281     198     8   .143     40.2     28     1.2    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------    2.8     17    13.6

CYCLE 2
      1 IDLE     114    .856   15.29     80   16.269    1634      12     174     3   .232      2.9     40      .6    0
      2 16 HG     53    .161   14.18   2021   14.398    7150      28     162   333   .077      2.2     12    25.7   20
      3 10 HG     38    .145   13.72   2814   13.906   10451      31     220   702   .147      4.5     32   103.2   43
      4 16 HG     38    .161   14.35   2267   14.552    7150      20     160   370   .077      1.6     12    28.5   20
      5 19 HG     38    .180   15.20   1375   15.421    5509      15     130   163   .057       .8      7     9.3   11
      6 16 HG     36    .159   14.32   2414   14.518    7150      19     158   395   .077      1.5     12    30.4   20
      7  3 HG     34    .922   14.41   1860   15.369   14303      34    1733   575   .113      3.9    196    64.9   66
      8 16 HG     34    .169   14.38   2514   14.586    7150      18     167   409   .077      1.4     13    31.5   20
      9 C.T.    2143    .876    8.41    102   11.600    1401     280     214     4   .143     40.0     31      .6    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------    2.8     17    14.2

CYCLE 3
      1 IDLE     161    .808   15.55     77   16.532    1634      17     161     3   .232      4.0     37      .6    0
      2 16 HG     52    .155   14.28   2139   14.491    7150      28     154   350   .077      2.1     12    27.0   20
      3 10 HG     36    .147   13.83   2915   14.016   10451      29     221   722   .147      4.3     33   106.1   43
      4 16 HG     32    .165   14.34   2346   14.540    7150      17     164   383   .077      1.3     13    29.5   20
      5 19 HG     45    .194   15.31   1448   15.553    5509      17     139   170   .057      1.0      8     9.7   11
      6 16 HG     35    .166   14.33   2345   14.534    7150      19     165   383   .077      1.4     13    29.5   20
      7  3 HG     32    .868   14.47   1830   15.373   14303      32    1631   565   .113      3.6    184    63.9   66
      8 16 HG     35    .170   14.64   2671   14.848    7150      18     165   427   .077      1.4     13    32.9   20
      9 C.T.    2124    .847    8.30     81   11.441    1401     281     210     3   .143     40.2     30      .5    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------    2.9     17    14.5

CYCLE 4
      1 IDLE     161    .808   15.55     77   16.532    1634      17     161     3   .232      4.0     37      .6    0
      2 16 HG     48    .165   14.23   1920   14.447    7150      26     165   316   .077      2.0     13    24.3   20
      3 10 HG     40    .146   13.73   2810   13.919   10451      32     221   700   .147      4.8     33   103.0   43
      4 16 HG     31    .168   14.25   2224   14.451    7150      17     168   365   .077      1.3     13    28.1   20
      5 19 HG     44    .187   15.19   1371   15.425    5509      17     135   163   .057      1.0      8     9.3   11
      6 16 HG     37    .166   14.27   2246   14.476    7150      20     166   368   .077      1.5     13    28.4   20
      7  3 HG     40    .816   14.41   1783   15.269   14303      40    1544   554   .113      4.6    174    62.7   66
      8 16 HG     32    .171   14.34   2337   14.546    7150      17     170   381   .077      1.3     13    29.4   20
      9 C.T.    2219    .868    8.61    114   11.875    1401     283     207     4   .143     40.4     30      .6    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------    2.9     16    13.8

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------    2.8     17    13.9

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------    2.9     16    14.2

      FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.8) + 0.65(     2.9) =    2.882  (MASS)
                                               CO  0.35(      17) + 0.65(      16) =     16.6  (MASS)
                                               NO2 0.35(    13.9) + 0.65(    14.2) =   14.071  (MASS)
                                                                  CORRECTED NO2 =   13.152  (MASS)
```

```
3-21-72        ENGINE 1-1        RUN 3                                        K =  .98     HUM =  70  GR/LB
-----------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED       TOTAL     FUEL        ADJUSTED (MASS)       WT.       WEIGHTED (MASS)
MODE           HC      CO     CO2      NO    CARBON    CONS.       HC      CO     NO2    FACT.      HC      CO   NO2(K)  HP
-----------------------------------------------------------------------------------------------------------------

CYCLE 1
        1 IDLE        133    .920   13.84      81    14.904     1634       16     204      3   .232      3.7      47      .7    0
        2 16 HG        38    .149   12.59    2030    12.780     7150       23     168    377   .077      1.8      13    29.0   20
        3 10 HG        46    .141   12.19    3114    12.381    10451       42     240    973   .147      6.2      35   128.3   43
        4 16 HG        41    .150   12.71    2602    12.904     7150       25     158    479   .077      1.9      13    36.9   20
        5 19 HG        35    .160   13.36    1633    13.558     5509       15     131    220   .057       .9       7    12.6   11
        6 16 HG        37    .149   12.67    2626    12.859     7150       22     167    485   .077      1.7      13    37.3   20
        7  3 HG        25    .915   12.67    1651    13.612    14303       28    1942    576   .113      3.2     219    65.1   66
        8 16 HG        23    .166   12.68    2800    12.871     7150       14     186    516   .077      1.1      14    39.8   20
        9 C.T.       2100    .772    7.51     279    10.550     1401      301     207     12   .143     43.1      30     1.8    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     3.1      19    17.0

CYCLE 2
        1 IDLE        133    .920   13.84      81    14.904     1634       16     204      3   .232      3.7      47      .7    0
        2 16 HG        54    .148   12.59    2352    12.796     7150       33     167    436   .077      2.5      13    33.6   20
        3 10 HG        37    .140   12.15    3231    12.330    10451       34     240    909   .147      5.0      35   133.7   43
        4 16 HG        39    .152   12.59    2532    12.784     7150       24     172    470   .077      1.8      13    36.2   20
        5 19 HG        35    .160   13.37    1713    13.568     5509       15     131    231   .057       .9       7    13.2   11
        6 16 HG        36    .149   12.61    2661    12.798     7150       22     168    494   .077      1.7      13    38.0   20
        7  3 HG        43   1.118   12.69    1698    13.854    14303       48    2331    582   .113      5.4     263    65.8   66
        8 16 HG        31    .167   12.62    2905    12.820     7150       19     188    519   .077      1.4      14    40.0   20
        9 C.T.       2469    .198    7.48     146    10.345     1401      361      54      7   .143     51.7       8      .9    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     3.6      20    17.5

CYCLE 3
        1 IDLE        102   1.081   13.56     115    14.751     1634       12     242      4   .232      2.8      56     1.0    0
        2 16 HG        28    .150   12.51    2375    12.690     7150       17     171    444   .077      1.3      13    34.2   20
        3 10 HG        39    .143   12.06    3273    12.245    10451       36     247    927   .147      5.3      36   136.3   43
        4 16 HG        21    .150   12.50    2580    12.673     7150       13     171    483   .077      1.0      13    37.2   20
        5 19 HG        19    .154   13.34    1648    13.515     5509        8     127    223   .057       .5       7    12.7   11
        6 16 HG        38    .149   12.49    2623    12.680     7150       23     170    491   .077      1.8      13    37.8   20
        7  3 HG        43   1.112   12.62    1713    13.778    14303       48    2332    590   .113      5.4     263    66.7   66
        8 16 HG        17    .163   12.58    2937    12.761     7150       10     184    546   .077       .8      14    42.1   20
        9 C.T.       2268    .865    7.63     154    10.944     1401      314     224      7   .143     44.9      32      .9    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     3.1      22    17.8

CYCLE 4
        1 IDLE        102   1.081   13.56     115    14.751     1634       12     242      4   .232      2.8      56     1.0    0
        2 16 HG        34    .150   12.52    2486    12.707     7150       21     171    464   .077      1.6      13    35.8   20
        3 10 HG        23    .143   11.92    3165    12.088    10451       21     250    909   .147      3.2      37   133.5   43
        4 16 HG        20    .149   12.57    2797    12.741     7150       12     169    521   .077       .9      13    40.1   20
        5 19 HG        22    .169   13.32    1647    13.513     5509       10     139    223   .057       .6       8    12.7   11
        6 16 HG        23    .152   12.54    3069    12.717     7150       14     173    573   .077      1.1      13    44.1   20
        7  3 HG        36   1.200   12.64    1775    13.879    14303       40    2498    607   .113      4.5     282    68.6   66
        8 16 HG        23    .168   12.58    2921    12.773     7150       14     190    543   .077      1.1      15    41.8   20
        9 C.T.       2147    .821    7.44     149    10.580     1401      307     220      7   .143     43.9      31      .9    0
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     2.9      23    18.3

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------------   3.3      20    17.2

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------------   3.0      22    18.1

        FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.3) + 0.65(     3.0) =    3.102  (MASS)
                                                 CO  0.35(      20) + 0.65(      22) =     21.2  (MASS)
                                                 NO2 0.35(    17.2) + 0.65(    18.1) =   17.779  (MASS)
                                                                  CORRECTED NO2 =        17.477  (MASS)
```

ENGINE 1-1

EXPERIMENTAL 23 MODE EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-29-72 RUN 1                      ENGINE 1-1          STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------------------
               DYNA.          MAN.   FUEL  RATE                DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR  GM/HR     ALDE.     HC       CO       CO2      NO
--------------------------------------------------------------------------------------------
  1    600      0.0     0   17.7   3.5    1579       27   2352     .520     13.63      45
  2   1200      4.2     1   19.5   6.4    2903       33    519     .070     13.77      89
  3   1200     17.0     4   18.7   6.8    3098       27    778     .070     13.77     207
  4   1200     38.2     9   17.4   7.9    3593       92   1610     .100     15.26    1052
  5   1200     53.0    12   16.2   9.1    4137       53   1651     .100     14.05    1730
  6   1200    106.0    24   11.3  11.8    5334       93   1913     .110     14.18    3480
  7   1200    159.0    36    6.8  18.2    8246       75   1975     .520     14.05    3070
  8   1200    174.0    40    2.6  21.1    9553       94   1240     .610     13.18    2870
  9   1200    195.0    45     .8  28.1   12737       47   3372    4.500     10.55    1797
 10   1200    212.0    48    0.0  28.8   13064       37   3596    6.570      9.93     559
 11    600      0.0     0   17.6   3.5    1597       40   2721     .390     14.05      53
 12   1200      0.0     0   22.4   4.0    1796      101  54043     .420      6.30      13
 13   2300    218.0    95    1.8  57.6   26127       60   2461    4.980     11.24     875
 14   2300    201.0    88    2.2  46.1   20929       29   1690    2.730     12.59    1887
 15   2300    179.0    78    3.0  40.8   18507       29    305     .670     13.33    2100
 16   2300    163.5    72    4.0  36.7   16629       16    220     .310     13.33    2225
 17   2300    109.0    48   10.3  26.5   11998       27    246     .130     12.47    3950
 18   2300     54.5    24   15.9  19.1    8673       23    284     .150     12.34    2750
 19   2300     39.3    17   17.7  15.5    7026       63    269     .130     12.71    2362
 20   2300     17.5     8   19.9  13.2    5997       29    372     .150     13.48    1237
 21   2300      4.4     2   21.1  11.3    5135       23    384     .210     13.63     688
 22    600      0.0     0   18.0   3.5    1597       25   2258     .310     13.63      53
 23   2300      0.0     0   25.0   5.5    2486       45  20917     .180      3.88       9
--------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP  ALDE.       HC        CO      NO2
--------------------------------------------------------------------------------------------
  1     .6    25.8     115     1.7   .070     0.0      R        R         R        R
  2    1.5    10.8      30     6.2   .060      .1    1.6    11.19      30.5      6.4
  3    1.3    17.3      31    15.3   .060      .2     .3     4.47       8.1      4.0
  4    4.6    37.3      47    80.9   .050      .4     .5     4.27       5.4      9.3
  5    3.3    47.7      58   166.0   .030      .4     .3     3.94       4.8     13.7
  6    7.4    70.5      92   425.6   .060     1.5     .3     2.91       3.4     17.6
  7    9.0   110.3     587   569.2  0.000     0.0     .2     3.04      16.1     15.7
  8   13.9    85.2     846   654.2   .040     1.6     .4     2.14      21.3     16.5
  9    8.4   279.1    7524   494.0  0.000     0.0     .2     6.26     168.9     11.1
 10    6.2   278.7   10283   143.8  0.000     0.0     .1     5.75     212.3      3.0
 11     .9    29.5      85     1.9   .070     0.0      R        R         R        R
 12    3.2   800.7     126      .6   .120     0.0      R        R         R        R
 13   20.5   390.5   15962   460.9   .025     2.4     .2     4.09     167.2      4.8
 14    8.5   228.3    7451   846.7   .055     4.8     .1     2.59      84.7      9.6
 15    9.2    40.2    1785   919.6   .035     2.7     .1      .51      22.8     11.7
 16    4.2    26.7     762   899.1   .060     4.3     .1      .37      10.6     12.6
 17    5.5    23.3     250  1246.3   .060     2.9     .1      .49       5.2     26.1
 18    3.4    19.7     210   632.5  0.000     0.0     .1      .83       8.8     26.5
 19    7.4    14.7     143   428.3   .065     1.1     .4      .85       8.3     24.9
 20    2.7    16.3     133   180.3  0.000     0.0     .4     2.13      17.4     23.6
 21    1.9    14.2     157    84.4  0.000     0.0    1.0     7.43      82.2     44.2
 22     .6    25.4      71     2.0   .080     0.0      R        R         R        R
 23    3.9   845.2     147     1.2   .060     0.0      R        R         R        R

CYCLE COMPOSITE      HC       8.623    GRAM/BHP HR
                     CO      46.081    GRAM/BHP HR
                     NO2     13.823    GRAM/BHP HR
                     ALDE      .206    GRAM/BHP HR
                     BSFC      .661      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-29-72 RUN 2                         ENGINE 1-1          STATIONARY DYNAMOMETER
------------------------------------------------------------------------------------------
                DYNA.        MAN.   FUEL RATE                   DRY CONCENTRATION
MODE SPEED       LOAD    HP  VAC. LB/HR  GM/HR    ALDE.     HC       CO      CO2       NO
------------------------------------------------------------------------------------------
  1    600        0.0     0  17.9   3.5   1579      39    2266     .350    14.05       48
  2   1200        4.1     1  19.7   6.4   2903      24     360     .070    13.48      116
  3   1200       16.5     4  18.6   6.8   3098      33     771     .070    12.59      245
  4   1200       37.1     8  17.8   7.9   3593     156    1625     .100    13.77     1112
  5   1200       51.5    12  16.5   9.1   4137      52    1647     .100    13.77     1775
  6   1200      103.0    24  11.8  11.8   5334      63    1677     .070    13.48     3650
  7   1200      154.5    35   6.8  18.2   8246      41    1946     .310    13.91     3200
  8   1200      169.0    39   3.3  21.1   9553      92    1466     .470    13.33     2900
  9   1200      189.5    43    .3  28.1  12737      34    2560    4.070    11.36     1850
 10   1200      206.0    47   0.0  28.8  13064     104    3703    6.440     9.78      370
 11    600        0.0     0  18.0   3.5   1597      29    3471     .350    13.77       58
 12   1200        0.0     0  22.3   4.0   1796      62   53862     .420     6.64       14
 13   2300      210.0    92    .7  57.6  26127      76    2622    5.080    11.13      838
 14   2300      193.0    85   1.2  46.1  20929      31    1052    2.640    12.82     1575
 15   2300      172.0    75   3.0  40.8  18507      26     282     .470    13.48     2050
 16   2300      157.5    69   4.9  36.7  16629      12     208     .210    13.18     2650
 17   2300      105.0    46  10.5  26.5  11998      24     246     .130    12.47     4000
 18   2300       52.5    23  16.0  19.1   8673      63     324     .130    12.47     2850
 19   2300       37.8    17  17.6  15.5   7026      33     325     .130    12.82     2287
 20   2300       16.8     7  20.2  13.2   5997      23     417     .180    13.63     1212
 21   2300        4.2     2  21.3  11.3   5135      38     412     .250    13.77      538
 22    600        0.0     0  18.0   3.5   1597      32    2263     .310    13.91       58
 23   2300        0.0     0  24.9   5.5   2486      47   27116     .350     4.64       11
------------------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2  FAC.      HP  ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1     .9   24.5       76      1.7  .070     0.0      R       R        R        R
  2    1.1    7.7       30      8.2  .060      .1    1.2    8.17     32.1      8.8
  3    1.7   18.7       34     19.8  .060      .2     .5    4.97      9.1      5.2
  4    8.6   41.6       52     44.6  .050      .4    1.0    4.91      6.1     11.2
  5    3.3   48.6       60    173.7  .030      .4     .3    4.13      5.1     14.8
  6    5.3   65.2       55    471.2  .060     1.4     .2    2.77      2.3     20.0
  7    5.1  111.3      358    607.8 0.000     0.0     .1    3.15     10.1     17.2
  8   13.6  100.4      650    659.5  .040     1.5     .4    2.60     16.8     17.1
  9    6.0  207.8     6676    498.7 0.000     0.0     .1    4.80    154.2     11.5
 10   17.7  291.6    10243     96.7 0.000     0.0     .4    6.20    217.6      2.1
 11     .7   38.3       78      2.1  .070     0.0      R       R        R        R
 12    1.9  777.3      122       .7  .120     0.0      R       R        R        R
 13   26.0  415.9    16276    441.0  .025     2.3     .3    4.52    177.0      4.8
 14    9.0  141.4     7171    703.1  .055     4.6     .1    1.67     84.8      8.3
 15    7.5   37.4     1257    901.1  .035     2.6     .1     .50     16.7     12.0
 16    3.2   25.8      526   1090.9  .060     4.1     .0     .37      7.6     15.8
 17    5.0   23.3      250   1262.1  .060     2.8     .1     .51      5.4     27.4
 18    9.3   22.2      180    649.6 0.000     0.0     .4     .97      7.8     28.3
 19    3.9   17.6      142    411.0  .065     1.1     .2    1.06      8.6     24.8
 20    2.2   18.1      157    174.3 0.000     0.0     .3    2.46     21.4     23.7
 21    3.0   15.1      184     65.2 0.000     0.0    1.6    8.19    100.3     35.4
 22     .8   25.0       69      2.1  .080     0.0      R       R        R        R
 23    3.2  875.2      228      1.2  .060     0.0      R       R        R        R

 CYCLE COMPOSITE     HC       8.752     GRAM/BHP HR
                     CO      45.581     GRAM/BHP HR
                     NO2     14.648     GRAM/BHP HR
                     ALDE      .200     GRAM/BHP HR
                     BSFC      .685       LB/BHP HR
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-31-72 RUN 1                    ENGINE 1-1          STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------
                DYNA.          MAN.   FUEL RATE                DRY CONCENTRATION
MODE SPEED      LOAD    HP  VAC. LB/HR  GM/HR     ALDE.     HC        CO       CO2      NO
--------------------------------------------------------------------------------
  1    600       0.0     0  18.0   3.5   1579         0   2946      .210     14.18      54
  2   1200       4.1     1  20.3   6.4   2903         0    339      .100     13.91     101
  3   1200      16.5     4  18.6   6.8   3098         0    675      .100     13.33     195
  4   1200      37.2     8  17.6   7.9   3593         0   1642      .150     14.18    1100
  5   1200      51.8    12  16.7   9.1   4137         0   1766      .130     14.18    1875
  6   1200     103.5    24  11.6  11.8   5334         0   1749      .100     13.77    3900
  7   1200     155.2    35   6.5  18.2   8246         0   2029      .280     14.18    3400
  8   1200     170.0    39   3.3  21.1   9553         0   1604      .550     13.48    3050
  9   1200     190.5    44    .3  28.1  12737         0   2189     3.060     12.09    2100
 10   1200     207.0    47   0.0  28.8  13064         0   3517     5.350     10.78     550
 11    600       0.0     0  18.0   3.5   1597         0   4283      .250     13.48      57
 12   1200       0.0     0  22.5   4.0   1796         0  51502      .250      5.27      12
 13   2300     212.5    93    .8  57.6  26127         0   2580     5.290     11.13     750
 14   2300     195.5    86   1.3  46.1  20929         0   1366     2.440     12.47    1987
 15   2300     174.0    76   3.0  40.8  18507         0    327      .640     13.06    2075
 16   2300     159.0    70   4.8  36.7  16629         0    258      .310     12.94    2550
 17   2300     106.3    47  11.0  26.5  11998         0    250      .130     12.09    3700
 18   2300      53.2    23  16.5  19.1   8673         0    307      .130     12.47    2650
 19   2300      38.3    17  18.0  15.5   7026         0    314      .130     12.82    2250
 20   2300      17.0     7  20.3  13.2   5997         0    389      .130     13.67    1212
 21   2300       4.3     2  21.4  11.3   5135         0    373      .210     13.91     563
 22    600       0.0     0  18.0   3.5   1597         0   2220      .550     13.77      53
 23   2300       0.0     0  25.3   5.5   2486         0  24593      .280      4.27      10
--------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0    31.7      46     1.9  .070     0.0      I       R        R        R
  2    0.0     7.0      42     6.9  .060      .1    0.0    7.41     44.1      7.3
  3    0.0    15.5      46    14.9  .060      .2    0.0    4.09     12.3      3.9
  4    0.0    40.7      75    90.5  .050      .4    0.0    4.79      8.8     10.6
  5    0.0    50.4      75   177.8  .030      .4    0.0    4.26      6.3     15.0
  6    0.0    66.4      77   491.8  .060     1.4    0.0    2.81      3.2     20.8
  7    0.0   114.1     318   634.8 0.000     0.0    0.0    3.22      9.0     17.9
  8    0.0   108.0     748   681.7  .040     1.6    0.0    2.78     19.3     17.5
  9    0.0   181.4    5123   577.8 0.000     0.0    0.0    4.17    117.7     13.3
 10    0.0   278.7    8566   144.7 0.000     0.0    0.0    5.89    181.1      3.1
 11    0.0    48.3      57     2.1  .070     0.0      I       R        R        R
 12    0.0   867.0      85      .7  .120     0.0      I       R        R        R
 13    0.0   404.2   16740   390.1  .025     2.3    0.0    4.34    179.9      4.2
 14    0.0   189.9    6856   917.8  .055     4.7    0.0    2.22     80.1     10.7
 15    0.0    44.0    1742   928.4  .035     2.7    0.0     .58     22.9     12.2
 16    0.0    32.3     784  1060.4  .060     4.2    0.0     .46     11.3     15.2
 17    0.0    24.5     257  1203.6  .060     2.8    0.0     .53      5.5     25.9
 18    0.0    21.1     180   604.1 0.000     0.0    0.0     .90      7.7     25.9
 19    0.0    17.0     142   404.3  .065     1.1    0.0    1.01      8.5     24.1
 20    0.0    16.9     114   174.9 0.000     0.0    0.0    2.27     15.3     23.5
 21    0.0    13.5     154    67.7 0.000     0.0    0.0    7.27     82.7     36.4
 22    0.0    24.4     122     1.9  .080     0.0      I       R        R        R
 23    0.0   872.2     201     1.2  .060     0.0      I       R        R        R

CYCLE COMPOSITE     HC      9.346    GRAM/BHP HR
                    CO     46.484    GRAM/BHP HR
                    NO2    14.835    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .678      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   3-31-72 RUN 2                    ENGINE 1-1           STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------
                 DYNA.        MAN.   FUEL RATE                DRY CONCENTRATION
MODE SPEED       LOAD    HP   VAC. LB/HR  GM/HR    ALDE.     HC        CO      CO2     NO
-----------------------------------------------------------------------------------
  1    600        0.0     0   18.0   3.5   1579        0   2999      .310    13.91     42
  2   1200        4.1     1   20.2   6.4   2903        0    282      .100    13.63    100
  3   1200       16.5     4   18.6   6.8   3098        0    783      .100    12.71    230
  4   1200       37.2     8   17.7   7.9   3593        0   1693      .130    13.77   1112
  5   1200       51.8    12   16.6   9.1   4137        0   1736      .100    13.63   1675
  6   1200      103.5    24   11.6  11.8   5334        0   1801      .100    13.48   3350
  7   1200      155.2    35    6.6  18.2   8246        0   2044      .350    13.63   3200
  8   1200      170.0    39    3.3  21.1   9553        0   1441      .420    13.18   3050
  9   1200      190.5    44     .3  28.1  12737        0   2792     3.010    11.60   1975
 10   1200      207.0    47    0.0  28.8  13064        0   3439     5.030    10.78    650
 11    600        0.0     0   18.0   3.5   1597        0   3043      .250    13.48     53
 12   1200        0.0     0   22.5   4.0   1796        0  55627      .310     6.13     14
 13   2300      212.5    93     .8  57.6  26127        0   2510     5.140    11.24    900
 14   2300      195.5    86    1.3  46.1  20929        0   1324     2.560    12.71   2075
 15   2300      174.0    76    3.0  40.8  18507        0    283      .850    13.33   2125
 16   2300      159.0    70    4.8  36.7  16629        0    202      .280    13.18   2500
 17   2300      106.3    47   11.0  26.5  11998        0    167      .130    12.09   3700
 18   2300       53.2    23   16.4  19.1   8673        0    223      .130    12.47   2850
 19   2300       38.3    17   18.0  15.5   7026        0    241      .130    12.82   2325
 20   2300       17.0     7   20.2  13.2   5997        0    298      .150    13.48   1250
 21   2300        4.3     2   21.3  11.3   5135        0    322      .210    13.77    700
 22    600        0.0     0   18.0   3.5   1597        0   2527      .390    13.48     56
 23   2300        0.0     0   25.2   5.5   2486        0  22855      .250     3.95     11
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP  ALDE.      HC       CO      NO2
-----------------------------------------------------------------------------------
  1   0.0    32.6       68     1.5   .070     0.0      I       R        R        R
  2   0.0     5.9       43     7.0   .060      .1    0.0    6.28     45.1      7.4
  3   0.0    18.8       49    18.4   .060      .2    0.0    4.98     12.8      4.9
  4   0.0    43.2       67    94.3   .050      .4    0.0    5.09      7.9     11.1
  5   0.0    51.6       60   165.5   .030      .4    0.0    4.36      5.1     14.0
  6   0.0    69.8       78   431.2   .060     1.4    0.0    2.95      3.3     18.2
  7   0.0   118.8      411   617.7  0.000     0.0    0.0    3.35     11.6     17.4
  8   0.0   100.2      590   703.8   .040     1.6    0.0    2.58     15.2     18.1
  9   0.0   238.9     5201   560.9  0.000     0.0    0.0    5.49    119.5     12.9
 10   0.0   278.1     8217   174.5  0.000     0.0    0.0    5.88    173.7      3.7
 11   0.0    34.6       57     2.0   .070     0.0      I       R        R        R
 12   0.0   832.5       94      .7   .120     0.0      I       R        R        R
 13   0.0   394.4    16311   469.4   .025     2.3    0.0    4.24    175.3      5.0
 14   0.0   179.9     7027   936.1   .055     4.7    0.0    2.10     82.1     10.9
 15   0.0    36.8     2236   918.9   .035     2.7    0.0     .48     29.4     12.1
 16   0.0    25.0      698  1023.9   .060     4.2    0.0     .36     10.0     14.7
 17   0.0    16.4      257  1204.4   .060     2.8    0.0     .35      5.5     25.9
 18   0.0    15.3      180   650.1  0.000     0.0    0.0     .66      7.7     27.9
 19   0.0    13.0      142   418.0   .065     1.1    0.0     .78      8.5     24.9
 20   0.0    13.1      133   182.2  0.000     0.0    0.0    1.76     17.9     24.5
 21   0.0    11.8      155    85.2  0.000     0.0    0.0    6.34     83.5     45.8
 22   0.0    28.6       89     2.1   .080     0.0      I       R        R        R
 23   0.0   876.0      194     1.4   .060     0.0      I       R        R        R

CYCLE COMPOSITE    HC      9.047    GRAM/BHP HR
                   CO     46.644    GRAM/BHP HR
                   NO2    14.774    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .678      LB/BHP HR
```

```
                           PROJECT 11-2877-01  CONTROL TECHNOLOGY
    4-03-72 RUN 1                          ENGINE 1-1          STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------------
                   DYNA.          MAN.   FUEL  RATE                  DRY CONCENTRATION
MODE SPEED         LOAD    HP    VAC. LB/HR  GM/HR    ALDE.     HC       CO       CO2     NO
-----------------------------------------------------------------------------------------
  1    600          0.0     0    18.2    3.5   1579      35   3400     .520     13.91     44
  2   1200          4.1     1    20.3    6.4   2903      26    452     .100     14.05     70
  3   1200         16.5     4    18.5    6.8   3098      43    896     .070     12.94    215
  4   1200         37.2     8    17.5    7.9   3593      78   1982     .150     14.18    963
  5   1200         51.7    12    16.5    9.1   4137      49   2013     .130     14.05   1587
  6   1200        103.5    24    11.5   11.8   5334      95   1744     .070     13.48   3200
  7   1200        155.0    35     6.5   18.2   8246      91   2268     .440     14.05   2750
  8   1200        169.5    39     3.2   21.1   9553      67   1526     .490     13.63   2550
  9   1200        190.0    43      .3   28.1  12737      62   3107    3.890     11.48   1563
 10   1200        207.0    47     0.0   28.8  13064      36   3513    4.980     11.01    575
 11    600          0.0     0    18.2    3.5   1597      55   4227     .280     13.48     50
 12   1200          0.0     0    22.5    4.0   1796     145  62193     .350      5.50     12
 13   2300        212.0    93      .8   57.6  26127      50   2739    5.290     11.01    663
 14   2300        195.0    85     1.2   46.1  20929      49   1360    2.870     12.34   1662
 15   2300        174.0    76     3.0   40.8  18507      36    299     .810     13.18   1688
 16   2300        159.0    70     4.6   36.7  16629      24    174     .280     13.18   1800
 17   2300        106.0    46    10.8   26.5  11998      19    195     .100     12.22   3250
 18   2300         53.0    23    16.3   19.1   8673      36    251     .100     12.47   2150
 19   2300         38.2    17    17.9   15.5   7026      26    285     .100     12.71   1925
 20   2300         17.0     7    20.3   13.2   5997      22    366     .150     13.33   1000
 21   2300          4.2     2    21.3   11.3   5135      39    394     .180     13.48    550
 22    600          0.0     0    18.0    3.5   1597      47   2705     .250     13.48     53
 23   2300          0.0     0    25.2    5.5   2486      40  22733     .150      3.45     11
-----------------------------------------------------------------------------------------
          CALCULATED GRAM/HR             WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2     FAC.       HP  ALDE.      HC       CO      NO2
-----------------------------------------------------------------------------------------
  1     .8    36.3     112     1.6    .020       0.0     R        R        R        R
  2    1.2     9.3      41     4.8    .060        .1    1.2     9.78     43.7      5.0
  3    2.2    21.2      33    16.9    .060        .2     .6     5.61      8.8      4.5
  4    4.2    49.0      75    79.0    .050        .4     .5     5.77      8.8      9.3
  5    3.1    57.9      76   151.6    .030        .4     .3     4.90      6.4     12.8
  6    7.9    67.8      55   412.9    .060       1.4     .3     2.87      2.3     17.5
  7   11.0   127.1     498   511.6   0.000       0.0     .3     3.59     14.1     14.4
  8    9.7   102.2     662   566.6    .040       1.5     .3     2.64     17.1     14.6
  9   10.4   252.4    6383   421.4   0.000       0.0     .3     5.81    147.0      9.7
 10    6.2   280.8    8042   152.6   0.000       0.0     .1     5.94    170.0      3.2
 11    1.3    47.6      64     1.9    .020       0.0     R        R        R        R
 12    4.7   925.6     105      .6    .120       0.0     R        R        R        R
 13   17.1   431.8   16845   346.7    .025       2.3     .2     4.65    181.4      3.7
 14   14.4   185.4    7907   752.8    .055       4.7     .2     2.17     92.6      8.8
 15   10.4    39.5    2160   739.6    .035       2.7     .1      .52     28.3      9.7
 16    6.4    21.5     698   737.3    .060       4.2     .1      .31     10.0     10.6
 17    4.1    19.0     196  1049.1    .060       2.8     .1      .41      4.2     22.6
 18    5.3    17.3     139   491.5   0.000       0.0     .2      .75      6.0     21.2
 19    3.1    15.6     111   349.8    .065       1.1     .2      .93      6.6     20.9
 20    2.1    16.2     134   147.3   0.000       0.0     .3     2.18     18.1     19.8
 21    3.2    14.8     136    68.4   0.000       0.0    1.7     7.96     73.4     36.9
 22    1.2    30.8      58     2.0    .080       0.0     R        R        R        R
 23    3.7   962.1     128     1.5    .060       0.0     R        R        R        R

CYCLE COMPOSITE    HC      9.976    GRAM/BHP HR
                   CO     49.157    GRAM/BHP HR
                   NO2    12.114    GRAM/BHP HR
                   ALDE     .221    GRAM/BHP HR
                   BSFC     .679      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
    4-03-72 RUN 2                           ENGINE 1-1            STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------------------
               DYNA.           MAN.   FUEL RATE                  DRY CONCENTRATION
MODE SPEED     LOAD     HP     VAC. LB/HR  GM/HR      ALDE.       HC        CO       CO2      NO
-----------------------------------------------------------------------------------------------
   1   600      0.0      0    18.0    3.5   1579          0     3951      .310     13.63      38
   2  1200      4.1      1    20.2    6.4   2903          0      338      .070     13.63      59
   3  1200     16.5      4    18.8    6.8   3098          0      784      .070     12.94     150
   4  1200     37.2      8    17.5    7.9   3593          0     1862      .100     13.77     975
   5  1200     51.7     12    16.5    9.1   4137          0     1846      .070     13.48    1737
   6  1200    103.5     24    11.5   11.8   5334          0     1873      .070     13.77    3300
   7  1200    155.0     35     6.5   18.2   8246          0     2050      .420     13.77    2800
   8  1200    169.5     39     3.5   21.1   9553          0     1456      .520     13.35    2800
   9  1200    190.0     43      .2   28.1  12737          0     2810     4.260     11.13    1500
  10  1200    207.0     47     0.0   28.8  13064          0     3566     5.350     11.24     650
  11   600      0.0      0    18.0    3.5   1597          0     3048      .440     13.48      49
  12  1200      0.0      0    22.5    4.0   1796          0    60390      .470      5.96      12
  13  2300    212.0     93      .8   57.6  26127          0     2899     5.030     11.24     788
  14  2300    195.0     85     1.2   46.1  20929          0     1368     2.360     12.82    1675
  15  2300    174.0     76     3.0   40.8  13507          0      283      .520     13.63    2007
  16  2300    159.0     70     4.6   36.7  16629          0      213      .180     13.48    2345
  17  2300    106.0     46    10.8   26.5  11948          0      221      .100     12.34    3720
  18  2300     53.0     23    16.3   19.1   8673          0      278      .130     12.47    2650
  19  2300     38.2     17    18.0   15.5   7026          0      287      .100     12.94    2230
  20  2300     17.0      7    20.3   13.2   5997          0      369      .130     13.63    1182
  21  2300      4.2      2    21.3   11.3   5135          0      377      .180     13.63     607
  22   600      0.0      0    18.0    3.5   1597          0     2397      .640     13.48      54
  23  2300      0.0      0    25.2    5.5   2486          0    23640      .350      3.95      11
-----------------------------------------------------------------------------------------------
         CALCULATED GRAM/HR            WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.       HP  ALDE.      HC        CO       NO2
-----------------------------------------------------------------------------------------------
   1   0.0    43.5       69      1.4   .070      0.0      I       R         R         R
   2   0.0     7.1       30      4.1   .060       .1    0.0    7.55      31.6       4.4
   3   0.0    18.6       33     11.8   .060       .2    0.0    4.91       8.9       3.1
   4   0.0    47.6       52     82.7   .050       .4    0.0    5.60       6.1       9.7
   5   0.0    55.6       43    173.7   .030       .4    0.0    4.71       3.6      14.7
   6   0.0    71.2       54    416.6   .060      1.4    0.0    3.01       2.3      17.6
   7   0.0   117.4      486    532.5  0.000      0.0    0.0    3.32      13.7      15.0
   8   0.0    99.2      716    633.6   .040      1.5    0.0    2.56      18.5      16.4
   9   0.0   228.4     6994    404.8  0.000      0.0    0.0    5.26     161.1       9.3
  10   0.0   274.9     8331    166.4  0.000      0.0    0.0    5.81     176.1       3.5
  11   0.0    34.2      100      1.8   .070      0.0      I       R         R         R
  12   0.0   870.0      137       .6   .120      0.0      I       R         R         R
  13   0.0   457.4    16031    412.5   .025      2.3    0.0    4.93     172.7       4.4
  14   0.0   187.0     6514    759.9   .055      4.7    0.0    2.19      76.3       8.9
  15   0.0    36.9     1371    870.0   .035      2.7    0.0     .48      18.0      11.4
  16   0.0    25.9      442    946.3   .060      4.2    0.0     .37       6.3      13.6
  17   0.0    21.3      194   1189.0   .060      2.8    0.0     .46       4.2      25.6
  18   0.0    19.1      180    604.3  0.000      0.0    0.0     .82       7.8      26.0
  19   0.0    15.4      109    398.0   .065      1.1    0.0     .92       6.5      23.8
  20   0.0    16.0      114    170.6  0.000      0.0    0.0    2.16      15.4      23.0
  21   0.0    14.0      135     74.8  0.000      0.0    0.0    7.52      72.6      40.3
  22   0.0    26.7      144      2.0   .080      0.0      I       R         R         R
  23   0.0   881.8      264      1.3   .060      0.0      I       R         R         R

CYCLE COMPOSITE      HC      9.443   GRAM/BHP HR
                     CO     43.523   GRAM/BHP HR
                     NO2    13.678   GRAM/BHP HR
                     ALDE    0.000   GRAM/BHP HR
                     BSFC     .679     LB/BHP HR
```

APPENDIX C

EMISSION RESULTS FROM ENGINE 1-2

TABULAR FORM

ENGINE 1-2

NINE MODE FTP EMISSION RESULTS

CONCENTRATION BASIS

```
      4-6-72        ENGINE 1-2        RUN-2                              K =1.083      HUM = 101  GR/LB
      ------------------------------------------------------------------------------------------------------------
      FEDERAL      CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING        W E I G H T E D
      MODE          HC      CO     CO2     NO      FACTOR      HC     CO    NO      FACTOR        HC      CO        NO
      ------------------------------------------------------------------------------------------------------------
CYCLE 1
      1 IDLE       1136  1.420  11.660     80     1.066     1211  1.514    85     .036       43.612    .055     3.071
      2 16'HG        95   .670  13.790   1083     1.020       97   .683  1105     .089        8.623    .061    98.302
      3 10'HG        61   .210  13.280   2550     1.078       66   .226  2749     .257       16.900    .058   706.465
      4 16'HG        86   .790  13.790   1105     1.016       87   .802  1122     .089        7.773    .071    99.875
      5 19'HG       179  1.610  13.130    332     1.019      182  1.845   338     .047        8.574    .087    15.902
      6 16'HG        68   .740  13.800   1143     1.016       69   .752  1162     .089        7.461    .067   103.403
      7  3'HG        42   .340  13.340   2438     1.070       45   .364  2608     .283       12.714    .103   738.035
      8 16'HG        82   .760  13.670   1096     1.026       84   .779  1124     .089        7.485    .069   100.038
      9 C.T.       3027  1.870   4.340    123     1.697     5137  3.174   209     .021      107.877    .067     4.384
      SUM-----------(CYCLE COMPOSITE)------------------------------------------------     221.519    .637  1869.474
CYCLE 2
      1 IDLE       1136  1.420  11.660     80     1.066     1211  1.514    85     .036       43.612    .055     3.071
      2 16'HG       154   .890  13.560   1069     1.023      158   .911  1094     .089       14.024    .081    97.348
      3 10'HG        70   .230  13.050   2540     1.045       77   .252  2782     .257       19.701    .065   714.870
      4 16'HG        93   .770  13.620   1161     1.028       96   .792  1193     .089        8.509    .070   106.219
      5 19'HG       108  1.850  13.680    347     1.027      111  1.900   356     .047        5.212    .089    16.746
      6 16'HG        88   .820  13.570   1066     1.030       91   .845  1119     .089        8.068    .075    99.572
      7  3'HG        46   .460  13.140   2476     1.081       50   .497  2675     .283       14.066    .141   757.117
      8 16'HG        82   .850  13.490   1093     1.035       85   .880  1132     .089        7.557    .078   100.726
      9 C.T.       3685  2.310   4.660    161     1.480     5455  3.420   238     .021      114.559    .072     5.005
      SUM-----------(CYCLE COMPOSITE)------------------------------------------------     235.308    .726  1900.674
CYCLE 3
      1 IDLE       1120  1.470  11.590    144     1.071     1200  1.575   154     .036       43.196    .057     5.554
      2 16'HG       155   .920  13.470   1116     1.024      159   .946  1148     .089       14.189    .084   102.161
      3 10'HG        71   .300  13.060   2441     1.091       77   .327  2664     .257       19.913    .084   684.624
      4 16'HG        91   .790  13.550   1083     1.033       94   .816  1118     .089        8.362    .073    99.522
      5 19'HG       125  1.770  13.060    351     1.030      129  1.823   361     .047        6.050    .086    16.989
      6 16'HG        91   .920  13.460   1270     1.034       94   .952  1314     .089        8.377    .085   116.914
      7  3'HG        44   .440  12.940   2396     1.098       48   .483  2630     .283       13.671    .137   744.423
      8 16'HG        77   .750  13.220   1037     1.060       82   .795  1099     .089        7.265    .071    97.838
      9 C.T.       2818  1.870   4.140    151     1.786     5033  3.340   270     .021      105.695    .070     5.664
      SUM-----------(CYCLE COMPOSITE)------------------------------------------------     226.719    .746  1873.689
CYCLE 4
      1 IDLE       1120  1.470  11.590    144     1.071     1200  1.575   154     .036       43.196    .057     5.554
      2 16'HG       146   .840  13.430   1089     1.035      151   .870  1127     .089       13.451    .077   100.327
      3 10'HG        63   .230  13.000   2520     1.100       69   .253  2772     .257       17.808    .065   712.338
      4 16'HG        88   .810  13.460   1102     1.039       91   .841  1145     .089        8.135    .075   101.872
      5 19'HG       115  1.870  12.910    351     1.038      119  1.941   364     .047        5.610    .091    17.124
      6 16'HG        90   .780  13.430   1219     1.042       94   .813  1270     .089        8.345    .072   113.034
      7  3'HG        45   .410  13.650   2470     1.040       49   .447  2692     .283       13.880    .126   761.872
      8 16'HG        82   .870  13.420   1158     1.036       85   .901  1200     .089        7.562    .080   106.792
      9 C.T.       3290  2.080   4.430    194     1.607     5287  3.342   312     .021      111.025    .070     6.547
      SUM-----------(CYCLE COMPOSITE)------------------------------------------------     229.014    .714  1925.460

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------  228.414    .682  1885.074

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------  227.866    .730  1899.574

      FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  228.414) + 0.65*(  227.866) =   228.058  PPM
                                                  CO    0.35*(     .682) + 0.65*(     .730) =      .713  PERCENT
                                                  NO    0.35*( 1885.074) + 0.65*( 1899.574) =  1894.499  PPM
                                                                            CORRECTED NO =  2051.652  PPM

      DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.E**-C)
```

```
     4-6-72        ENGINE 1-2         RUN-3                                      K =1.113      HUM = 113  GR/LB
   ---------------------------------------------------------------------------------------------------------------
   FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION    A D J U S T E D   WEIGHTING        W E I G H T E D
   MODE             HC      CO     CO2    NO     FACTOR    HC      CO    NO     FACTOR        HC      CO       NO
   ---------------------------------------------------------------------------------------------------------------
CYCLE 1
   1 IDLE          909  1.280  12.310     94     1.041    946  1.332     98      .036      34.059    .048     3.522
   2 16'HG         161   .710  13.740   1103     1.016    164   .722   1121      .089      14.561    .064    99.757
   3 10'HG          87   .270  13.210   2518     1.079     94   .291   2717      .257      24.124    .075   698.218
   4 16'HG         102   .790  13.800   1171     1.014    103   .801   1187      .089       9.202    .071   105.638
   5 19'HG         150  1.840  13.280    322     1.010    151  1.858    325      .047       7.118    .087    15.279
   6 16'HG          94   .780  13.630   1064     1.012     95   .790   1077      .089       8.470    .070    95.876
   7  3'HG          54   .420  13.350   2507     1.065     57   .447   2669      .283      16.271    .127   755.414
   8 16'HG          87   .740  13.740   1137     1.019     89   .805   1159      .089       7.890    .072   103.121
   9 C.T.         3793  2.170   4.720    133     1.464   5555  3.178    195      .021     116.647    .067     4.090
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------     238.342    .681  1880.916
CYCLE 2
   1 IDLE          909  1.280  12.310     94     1.041    946  1.332     98      .036      34.059    .048     3.522
   2 16'HG         115   .800  13.650   1212     1.023    118   .818   1240      .089      10.470    .073   110.347
   3 10'HG          60   .250  13.170   2443     1.085     65   .271   2651      .257      16.736    .070   681.435
   4 16'HG          92   .870  13.590   1165     1.027     94   .893   1196      .089       8.406    .079   106.443
   5 19'HG         136  1.890  13.030    337     1.027    140  1.941    346      .047       6.563    .041    16.263
   6 16'HG          91   .780  13.600   1161     1.029     94   .603   1195      .089       8.336    .071   106.349
   7  3'HG          50   .410  13.280   2497     1.071     54   .439   2674      .283      15.154    .124   756.809
   8 16'HG          85   .850  13.470   1137     1.037     88   .881   1179      .089       7.843    .078   104.906
   9 C.T.         2984  1.740   4.230    128     1.742   5199  3.031    223      .021     109.174    .064     4.683
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------     216.741    .699  1890.757
CYCLE 3
   1 IDLE         1345  1.510  11.810    136     1.034   1391  1.562    141      .036      50.086    .056     5.064
   2 16'HG         120   .900  13.450   1102     1.034    124   .930   1139      .089      11.038    .083   101.366
   3 10'HG          64   .260  13.030   2528     1.096     70   .285   2771      .257      18.028    .073   712.110
   4 16'HG          88   .790  13.540   1086     1.033     91   .816   1122      .089       8.094    .073    99.892
   5 19'HG         113  1.750  13.040    342     1.033    122  1.807    353      .047       5.727    .085    16.598
   6 16'HG          88   .720  13.630   1113     1.029     91   .741   1146      .089       8.063    .066   101.975
   7  3'HG          49   .540  13.090   2481     1.081     53   .584   2682      .283      14.991    .165   759.028
   8 16'HG          88   .890  13.520   1164     1.031     91   .918   1200      .089       8.077    .082   106.838
   9 C.T.         3575  2.100   4.660    159     1.515   5416  3.181    241      .021     113.738    .067     5.059
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------     237.842    .750  1907.930
CYCLE 4
   1 IDLE         1345  1.510  11.610    136     1.034   1391  1.562    141      .036      50.086    .056     5.064
   2 16'HG         117   .910  13.420   1133     1.036    121   .942   1173      .089      10.784    .084   104.428
   3 10'HG          62   .250  13.030   2644     1.097     68   .274   2900      .257      17.474    .070   745.190
   4 16'HG          90   .860  13.470   1188     1.036     93   .891   1231      .089       8.298    .079   109.530
   5 19'HG         104  1.820  13.020    352     1.033    107  1.879    363      .047       5.047    .088    17.083
   6 16'HG          87   .740  13.500   1178     1.038     90   .768   1223      .089       8.040    .068   108.867
   7  3'HG          43   .360  13.060   2601     1.091     47   .393   2839      .283      13.280    .111   803.316
   8 16'HG          81   .780  13.440   1208     1.042     84   .813   1259      .089       7.511    .072   112.012
   9 C.T.         3623  2.210   4.670    192     1.497   5423  3.308    287      .021     113.875    .069     6.035
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------     234.396    .700  2011.524

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------     227.542    .690  1885.837

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------     236.119    .725  1959.727

   FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  227.542) + 0.65*(  236.119) =   233.117  PPM
                                               CO    0.35*(     .690) + 0.65*(     .725) =      .712  PERCENT
                                               NO    0.35*( 1885.837) + 0.65*( 1959.727) =  1933.866  PPM
                                                                          CORRECTED NO =  2152.848  PPM

   DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
          4-6-72        ENGINE 1-2        RUN-4                                  K =1.088     HUM = 103  GR/LB
          ----------------------------------------------------------------------------------------------------------
          FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION    A D J U S T E D   WEIGHTING        W E I G H T E D
          MODE            HC      CO     CO2      NO     FACTOR     HC      CO    NO     FACTOR        HC      CO       NO
          ----------------------------------------------------------------------------------------------------------
CYCLE 1
          1 IDLE         1440    .970  11.160      88     1.098      1582  1.066     97      .036       56.945   .038     3.480
          2 16'HG         354    .640  13.750    1002     1.063       355   .642   1005      .089       31.610   .057    89.472
          3 10'HG          88    .200  13.090    2579     1.091        96   .218   2815      .257       24.684   .056   723.418
          4 16'HG         101    .760  13.620    1133     1.024       103   .778   1160      .089        9.205   .069   103.265
          5 19'HG         140   1.650  13.120     332     1.029       144  1.697    342      .047        6.768   .080    16.051
          6 16'HG          98    .660  13.720    1195     1.024       100   .676   1224      .089        8.934   .060   108.941
          7  3'HG          61    .430  13.310    2481     1.067        65   .459   2647      .283       18.418   .130   749.089
          8 16'HG          90    .710  13.670    1156     1.027        92   .729   1187      .089        8.224   .065   105.636
          9 C.T.         3163   1.850   4.240     124     1.690      5345  3.126    210      .021      112.240   .066     4.400
          SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    277.029   .621  1903.753
CYCLE 2
          1 IDLE         1440    .970  11.160      88     1.098      1582  1.066     97      .036       56.945   .038     3.480
          2 16'HG         145    .630  13.450    1564     1.042       151   .656   1629      .089       13.441   .058   144.979
          3 10'HG          81    .290  13.040    2486     1.092        88   .317   2716      .257       22.742   .081   697.992
          4 16'HG         102    .810  13.490    1126     1.035       106   .839   1166      .089        9.399   .075   103.755
          5 19'HG         153   1.870  12.420     322     1.034       158  1.934    333      .047        7.437   .091    15.652
          6 16'HG          97    .840  13.500    1137     1.034       100   .868   1176      .089        8.926   .077   104.622
          7  3'HG          53    .430  13.050    2547     1.088        58   .468   2772      .283       16.325   .132   784.524
          8 16'HG          86    .790  13.500    1273     1.037        89   .819   1320      .089        7.934   .073   117.445
          9 C.T.         2555   1.720   4.300     151     1.831      4678  3.149    276      .021       98.239   .066     5.806
          SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    241.388   .692  1978.254
CYCLE 3
          1 IDLE         1159   1.510  11.760     186     1.053      1221  1.590    196      .036       43.946   .057     7.053
          2 16'HG         127    .860  13.400    1165     1.038       132   .893   1209      .089       11.734   .079   107.641
          3 10'HG          66    .230  12.930    2703     1.105        73   .254   2988      .257       18.751   .065   767.956
          4 16'HG          92    .770  13.400    1258     1.044        96   .804   1314      .089        8.551   .072   116.926
          5 19'HG         145   1.720  12.880     372     1.043       151  1.795    388      .047        7.111   .084    18.243
          6 16'HG          93    .710  13.410    1230     1.046        97   .742   1286      .089        8.656   .066   114.480
          7  3'HG          53    .440  13.070    2546     1.086        58   .478   2766      .283       16.294   .135   782.747
          8 16'HG          87    .810  13.460    1194     1.039        90   .841   1240      .089        8.043   .075   110.385
          9 C.T.         2832   1.870   4.360     194     1.736      4916  3.246    337      .021      103.231   .068     7.072
          SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    226.318   .702  2032.502
CYCLE 4
          1 IDLE         1159   1.510  11.760     186     1.053      1221  1.590    196      .036       43.946   .057     7.053
          2 16'HG         149    .870  13.290    1434     1.044       156   .908   1497      .089       13.847   .081   133.270
          3 10'HG          75    .310  13.020    2427     1.044        82   .339   2655      .257       21.084   .087   682.273
          4 16'HG          94    .810  13.360    1143     1.046        98   .847   1195      .089        8.748   .075   106.374
          5 19'HG         150   1.800  12.820     415     1.045       157  1.880    433      .047        7.364   .088    20.373
          6 16'HG          89    .770  13.260    1530     1.055        94   .813   1614      .089        8.358   .072   143.690
          7  3'HG          49    .470  13.060    2540     1.086        53   .511   2759      .283       15.064   .144   780.862
          8 16'HG          81    .780  13.170    1178     1.062        86   .829   1252      .089        7.659   .074   111.391
          9 C.T.         2975   2.030   4.340     227     1.692      5035  3.435    384      .021      105.729   .072     8.067
          SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    231.801   .752  1993.355

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------------    259.208   .657  1941.004

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------------    229.059   .727  2012.929

          FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  259.208) + 0.65*(  229.059) =    239.611  PPM
                                                      CO    0.35*(     .657) + 0.65*(     .727) =       .702  PERCENT
                                                      NO    0.35*( 1941.004) + 0.65*( 2012.929) =   1987.755  PPM
                                                                                 CORRECTED NO =   2163.376  PPM

          DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

ENGINE 1-2

NINE MODE FTP EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
   4-6-72        ENGINE 1-2        RUN-2                          H = 1.07     HUM = 101  GR/LB
--------------------------------------------------------------------------------------------------------------
MASS        CONCENTRATION AS MEASURED      TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
MODE         HC      CO     CO2     NO    CARBON   CONS.       HC      CO     NO2   FACT.      HC       CO   NO2(K)  HP
--------------------------------------------------------------------------------------------------------------

CYCLE 1
   1 IDLE   1136   1.420  11.66     80   14.307    3074       264     616       6   .232     61.1      143     1.3    0
   2 16 HG    95    .620  13.78   1083   14.553   13284        94    1235     328   .077      7.2       95    25.3   38
   3 10 HG    61    .210  13.28   2550   13.556   19227        93     602    1201   .147     13.7       86   176.5   76
   4 16 HG    86    .290  13.74   1105   14.673   13284        84    1445     332   .077      6.5      111    25.6   38
   5 19 HG   179   1.810  13.13    332   15.133    9288       125    2365      71   .057      7.1      135     4.1   11
   6 16 HG    88    .740  13.80   1143   14.635   13284        86    1357     344   .077      6.6      104    26.5   38
   7  3 HG    42    .340  13.34   2438   13.725   26904        89    1346    1587   .113     10.0      152   179.3  120
   8 16 HG    82    .260  13.62   1096   14.519   13284        81    1405     333   .077      6.2      108    25.6   38
   9 C.T.   3027   1.820   4.34    123    9.479    2883       994    1149      12   .143    142.2      164     1.8    0
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------      7.0       30    12.6

CYCLE 2
   1 IDLE   1136   1.420  11.66     80   14.307    3074       264     616       6   .232     61.1      143     1.3    0
   2 16 HG   154    .890  13.56   1069   14.616   13284       151    1634     323   .077     11.6      126    24.8   38
   3 10 HG    70    .230  13.05   2540   13.356   19227       109     669    1214   .147     16.0       98   178.5   76
   4 16 HG    93    .720  13.62   1161   14.490   13284        92    1426     353   .077      7.1      110    27.2   38
   5 19 HG   108   1.850  13.08    347   15.047    9288        76    2431      75   .057      4.3      139     4.3   11
   6 16 HG    88    .920  13.57   1086   14.485   13284        87    1519     331   .077      6.7      117    25.5   38
   7  3 HG    46    .460  13.14   2476   13.650   26904        98    1831    1620   .113     11.1      207   183.1  120
   8 16 HG    82    .850  13.49   1093   14.429   13284        82    1581     334   .077      6.3      122    25.7   38
   9 C.T.   3685   2.310   4.66    161   10.950    2883      1048    1229      14   .143    149.8      176     2.0    0
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------      7.4       33    12.7

CYCLE 3
   1 IDLE   1120   1.470  11.59    144   14.270    3074       261     640      10   .232     60.4      148     2.4    0
   2 16 HG   155    .920  13.47   1116   14.557   13284       153    1696     338   .077     11.8      131    26.0   38
   3 10 HG    71    .300  13.06   2441   13.437   19227       110     867    1160   .147     16.1      127   170.5   76
   4 16 HG    91    .290  13.55   1083   14.438   13284        90    1468     331   .077      7.0      113    25.5   38
   5 19 HG   125   1.770  13.06    351   14.965    9288        88    2339      76   .057      5.0      133     4.3   11
   6 16 HG    91    .920  13.46   1270   14.478   13284        90    1705     387   .077      6.9      131    29.8   38
   7  3 HG    44    .440  12.94   2396   13.428   26904        95    1781    1594   .113     10.8      201   180.1  120
   8 16 HG    77    .750  13.22   1037   14.053   13284        79    1432     325   .077      6.1      110    25.1   38
   9 C.T.   2818   1.870   4.14    151    9.053    2883       969    1203      16   .143    138.6      172     2.3    0
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------      7.1       34    12.6

CYCLE 4
   1 IDLE   1120   1.470  11.59    144   14.270    3074       261     640      10   .232     60.4      148     2.4    0
   2 16 HG   146    .840  13.43   1089   14.428   13284       145    1562     333   .077     11.2      120    25.6   38
   3 10 HG    63    .230  13.00   2520   13.248   19227        98     672    1210   .147     14.5       99   177.8   76
   4 16 HG    88    .910  13.46   1102   14.365   13284        88    1513     338   .077      6.8      117    26.1   38
   5 19 HG   115   1.870  12.91    351   14.904    9288        82    2481      77   .057      4.6      141     4.4   11
   6 16 HG    90    .780  13.43   1219   14.307   13284        90    1463     376   .077      6.9      113    28.9   38
   7  3 HG    45    .410  13.05   2470   13.509   26904        97    1649    1633   .113     10.9      186   184.6  120
   8 16 HG    82    .870  13.47   1158   14.429   13284        82    1618     354   .077      6.3      125    27.3   38
   9 C.T.   3290   2.080   4.43    194   10.063    2883      1018    1204      18   .143    145.6      172     2.6    0
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------      7.2       33    12.9

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)--------------------------------      7.2       32    12.6

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)--------------------------------      7.1       34    12.7

   FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(      7.2) + 0.65(      7.1) =     7.162  (MASS)
                                            CO  0.35(       32) + 0.65(       34) =      32.8  (MASS)
                                            NO2 0.35(     12.6) + 0.65(     12.7) =    12.704  (MASS)
                                                                   CORRECTED NO2 =    13.569  (MASS)
   4-6-72        ENGINE 1-2        RUN=3                                         K = 1.09      HUM = 113  GR/LB
--------------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED     TOTAL    FUEL       ADJUSTED (MASS)        WT.         WEIGHTED (MASS)
MODE            HC      CO      CO2     NO   CARBON   CONS.       HC      CO    NO2   FACT.       HC      CO   NO2(K)  HP
--------------------------------------------------------------------------------------------------------------------
CYCLE 1
        1 IDLE      909   1.280   12.31     94   14.572    3074      207     545      7   .232     48.0     127     1.5    0
        2 16 HG     161    .710   13.74   1103   14.624   13284      158    1303    333   .077     12.2     100    25.6   38
        3 10 HG      87    .270   13.21   2518   13.574   19227      133     773   1184   .147     19.6     114   174.1   76
        4 16 HG     102    .790   13.80   1171   14.700   13284      100    1442    351   .077      7.7     111    27.1   38
        5 19 HG     150   1.840   13.28    322   15.282    9788      104    2381     68   .057      5.9     136     3.9   11
        6 16 HG      94    .780   13.83   1064   14.712   13284       92    1423    319   .077      7.1     110    24.6   38
        7  3 HG      54    .420   13.35   2507   13.828   26904      113    1651   1619   .113     12.8     187   183.0  120
        8 16 HG      87    .790   13.74   1137   14.624   13284       85    1450    343   .077      6.6     112    26.4   38
        9 C.T.     3793   2.170    4.72    133   10.986    2883     1075    1150     12   .143    153.7     164     1.7    0
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------------     7.4      31    12.6
CYCLE 2
        1 IDLE      909   1.280   12.31     94   14.572    3074      207     545      7   .232     48.0     127     1.5    0
        2 16 HG     115    .800   13.65   1212   14.574   13284      113    1473    367   .077      8.7     113    28.2   38
        3 10 HG      60    .250   13.17   2443   13.485   19227       92     720   1156   .147     13.6     106   170.0   76
        4 16 HG      92    .870   13.59   1165   14.559   13284       91    1603    353   .077      7.0     123    27.2   38
        5 19 HG     136   1.890   13.03    337   15.067    9788       95    2480     73   .057      5.4     141     4.1   11
        6 16 HG      91    .780   13.60   1161   14.478   13284       90    1446    354   .077      6.9     111    27.2   38
        7  3 HG      50    .410   13.28   2497   13.744   26904      106    1621   1623   .113     11.9     183   183.4  120
        8 16 HG      85    .850   13.47   1137   14.412   13284       85    1583    348   .077      6.5     122    26.8   38
        9 C.T.     2984   1.740    4.23    128    9.193    2883     1011    1102     13   .143    144.5     158     1.9    0
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------------     6.8      32    12.7
CYCLE 3
        1 IDLE     1345   1.510   11.81    136   14.773    3074      302     635      9   .232     70.1     147     2.2    0
        2 16 HG     120    .900   13.45   1102   14.480   13284      119    1668    336   .077      9.2     128    25.8   38
        3 10 HG      64    .260   13.03   2528   13.359   19227       99     756   1208   .147     14.6     111   177.6   76
        4 16 HG      88    .790   13.54   1086   14.425   13284       88    1470    332   .077      6.7     113    25.6   38
        5 19 HG     118   1.750   13.04    342   14.917    9788       84    2320     75   .057      4.8     132     4.2   11
        6 16 HG      88    .720   13.63   1113   14.445   13284       87    1338    340   .077      6.7     103    26.2   38
        7  3 HG      49    .540   13.09   2481   13.683   26904      104    2145   1620   .113     11.8     242   183.0  120
        8 16 HG      88    .890   13.52   1164   14.505   13284       87    1646    354   .077      6.7     127    27.3   38
        9 C.T.     3575   2.100    4.66    159   10.621    2883     1048    1151     14   .143    149.9     165     2.0    0
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------------     7.6      34    12.8
CYCLE 4
        1 IDLE     1345   1.510   11.81    136   14.773    3074      302     635      9   .232     70.1     147     2.2    0
        2 16 HG     117    .910   13.42   1133   14.456   13284      116    1689    346   .077      8.9     130    26.6   38
        3 10 HG      62    .250   13.03   2644   13.347   19227       96     727   1265   .147     14.2     107   185.9   76
        4 16 HG      90    .860   13.47   1188   14.427   13284       89    1600    363   .077      6.9     123    28.0   38
        5 19 HG     104   1.820   13.02    352   14.952    9788       74    2407     77   .057      4.2     137     4.4   11
        6 16 HG      87    .740   13.50   1178   14.334   13284       87    1385    362   .077      6.7     107    27.9   38
        7  3 HG      43    .360   13.06   2601   13.466   26904       93    1453   1725   .113     10.5     164   194.9  120
        8 16 HG      81    .780   13.44   1208   14.307   13284       81    1463    372   .077      6.3     113    28.7   38
        9 C.T.     3623   2.210    4.67    192   10.293    2883     1045    1192     17   .143    149.5     171     2.4    0
        SUM-----------(CYCLE COMPOSITE)------------------------------------------------------     7.5      32    13.5

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------     7.1      32    12.6

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------     7.5      33    13.1

        FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     7.1) + 0.65(     7.5) =     7.364  (MASS)
                                                 CO  0.35(      32) + 0.65(      33) =      32.7  (MASS)
                                                 NO2 0.35(    12.6) + 0.65(    13.1) =    12.960  (MASS)
                                                                   CORRECTED NO2 =    14.120  (MASS)
```

```
  4-6-72         ENGINE 1-2          RUN-4                              K = 1.07      HUM = 103  GR/LB
-----------------------------------------------------------------------------------------------------------
 MASS         CONCENTRATION AS MEASURED      TOTAL    FUEL      ADJUSTED (MASS)      WT.      WEIGHTED (MASS)
 MODE          HC      CO     CO2     NO    CARBON   CONS.     HC      CO    NO2   FACT.     HC      CO   NO2(K)  HP
-----------------------------------------------------------------------------------------------------------

CYCLE 1
 1 IDLE       1440    .920  11.16     88   13.685    3074     349     440      7   .232    81.0    102     1.5    0
 2 16 HG       354    .640  13.75   1002   14.772   13284     344    1163    299   .077    26.5     90    23.0   38
 3 10 HG        88    .200  13.09   2579   13.385   19227     137     580   1230   .147    20.1     85   180.8   76
 4 16 HG       101    .260  13.67   1133   14.539   13284     100    1403    344   .077     7.7    108    26.5   38
 5 19 HG       140   1.650  13.12    332   14.921    9788      99    2186     72   .057     5.7    125     4.1   11
 6 16 HG        98    .660  13.72   1195   14.486   13284      97    1223    364   .077     7.5     94    28.0   38
 7  3 HG        61    .430  13.31   2481   13.806   26904     128    1693   1605   .113    14.5    191   181.4  120
 8 16 HG        90    .710  13.67   1156   14.477   13284      89    1316    352   .077     6.9    101    27.1   38
 9 C.T.       3163   1.850   4.24    124    9.506    2883    1036    1133     12   .143   148.1    162     1.8    0
 SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     8.6     29    12.8

CYCLE 2
 1 IDLE       1440    .920  11.16     88   13.685    3074     349     440      7   .232    81.0    102     1.5    0
 2 16 HG       145    .630  13.45   1564   14.237   13284     146    1187    485   .077    11.3     91    37.3   38
 3 10 HG        81    .290  13.04   2486   13.417   19227     125     839   1183   .147    18.4    123   173.9   76
 4 16 HG       102    .810  13.49   1126   14.410   13284     102    1508    345   .077     7.8    116    26.5   38
 5 19 HG       153   1.870  12.92    322   14.955    9788     108    2472     70   .057     6.2    141     4.0   11
 6 16 HG        97    .840  13.50   1137   14.445   13284      96    1560    347   .077     7.4    120    26.7   38
 7  3 HG        53    .430  13.05   2547   13.537   26904     114    1726   1681   .113    12.9    195   189.9  120
 8 16 HG        86    .790  13.50   1273   14.383   13284      86    1474    390   .077     6.6    113    30.1   38
 9 C.T.       2555   1.720   4.30    151    8.779    2883     906    1141     16   .143   129.6    163     2.4    0
 SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     7.6     31    13.3

CYCLE 3
 1 IDLE       1159   1.510  11.76    186   14.522    3074     265     646     13   .232    61.5    150     3.0    0
 2 16 HG       127    .860  13.40   1165   14.397   13284     127    1603    357   .077     9.7    123    27.5   38
 3 10 HG        66    .230  12.93   2703   13.231   19227     104     675   1304   .147    15.2     99   191.7   76
 4 16 HG        92    .770  13.40   1258   14.269   13284      92    1448    389   .077     7.1    111    29.9   38
 5 19 HG       145   1.720  12.88    372   14.757    9788     104    2305     82   .057     5.9    131     4.7   11
 6 16 HG        93    .710  13.41   1230   14.220   13284      94    1340    381   .077     7.2    103    29.4   38
 7  3 HG        53    .440  13.07   2546   13.567   26904     114    1763   1676   .113    12.8    199   189.4  120
 8 16 HG        87    .810  13.46   1194   14.364   13284      87    1513    367   .077     6.7    117    28.2   38
 9 C.T.       2832   1.870   4.36    194    9.289    2883     949    1172     20   .143   135.7    168     2.9    0
 SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     7.1     32    13.7

CYCLE 4
 1 IDLE       1159   1.510  11.76    186   14.522    3074     265     646     13   .232    61.5    150     3.0    0
 2 16 HG       149    .870  13.29   1434   14.321   13284     149    1630    442   .077    11.5    126    34.0   38
 3 10 HG        75    .310  13.02   2427   13.411   19227     116     898   1155   .147    17.1    132   169.8   76
 4 16 HG        94    .810  13.36   1143   14.272   13284      94    1523    353   .077     7.3    117    27.2   38
 5 19 HG       150   1.800  12.82    415   14.782    9788     107    2408     91   .057     6.1    137     5.2   11
 6 16 HG        89    .770  13.26   1530   14.126   13284      90    1463    478   .077     7.0    113    36.8   38
 7  3 HG        49    .470  13.06   2540   13.583   26904     105    1880   1670   .113    11.8    212   188.7  120
 8 16 HG        81    .780  13.17   1178   14.037   13284      83    1491    370   .077     6.4    115    28.5   38
 9 C.T.       2975   2.030   4.34    227    9.583    2883     967    1234     23   .143   138.2    176     3.2    0
 SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     7.2     34    13.4

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------     8.1     30    13.0

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------     7.1     33    13.5

 FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     8.1) + 0.65(     7.1) =     7.455  (MASS)
                                          CO  0.35(      30) + 0.65(      33) =      32.2  (MASS)
                                          NO2 0.35(    13.0) + 0.65(    13.5) =    13.342  (MASS)
                                                             CORRECTED NO2 =    14.304  (MASS)
```

ENGINE 1-2

EXPERIMENTAL 23 MODE EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-07-72 RUN 1                 ENGINE 1-2           STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------
           DYNA.         MAN.   FUEL  RATE                  DRY CONCENTRATION
MODE SPEED  LOAD    HP   VAC. LB/HR  GM/HR    ALDE.     HC        CO       CO2      NO
--------------------------------------------------------------------------------
  1   550    0.0     0   18.5   6.3   3071      44  18687    1.090     9.64      43
  2  1200    7.5     2   20.0  12.4   5643      46   8332    2.600    11.01      68
  3  1200   30.0     7   19.0  14.1   6400      49   3384    2.360    11.48     114
  4  1200   67.6    15   17.4  16.2   7353      50   2766    2.110    11.84     235
  5  1200   93.9    21   16.4  18.1   8210      54   2803    1.870    11.24     420
  6  1200  187.5    43   11.0  23.9  10832      37   2349     .470    12.34    2000
  7  1200  281.0    64    1.2  33.9  15368      81    718     .130    11.24    1100
  8  1200  308.0    70    1.0  36.0  16339      64    664     .130    11.36    1750
  9  1200  345.0    79     .8  41.3  18720      78   2590    2.400    11.24    1400
 10  1200  375.0    86    0.0  46.9  21292      92   2881    3.240    10.78    1100
 11   550    0.0     0   18.5   6.8   3071      76  11068    1.300    10.25      46
 12  1200    0.0     0   22.5   6.3   2840      79  51914    1.270     5.16      14
 13  2300  370.0   162     .9  90.0  40824      82   3621    4.260    11.92     813
 14  2300  340.0   149    1.5  75.7  34347      70   1888    3.100    12.47    1262
 15  2300  303.0   133    3.4  70.1  31784     146    508     .390    13.48    2250
 16  2300  278.0   122    5.3  62.2  28218      26    772     .310    13.48    2400
 17  2300  185.0    81   10.5  46.6  21133      38    504     .130    12.94    2650
 18  2300   92.5    41   16.0  33.6  15223      31   1468     .520    13.48    1300
 19  2300   66.6    29   17.0  30.1  13640      41   1527     .670    13.48     950
 20  2300   29.6    13   19.0  25.1  11394      83   1640     .970    13.18     525
 21  2300    7.4     3   20.2  22.3  10124      32   2260    1.340    12.71     300
 22   550    0.0     0   18.5   6.8   3071      43  14303     .890    10.25      44
 23  2300    0.0     0   24.5   7.1   3239      76  27807     .420     2.81       8
--------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC      CO     NO2   FAC.     HP  ALDE.     HC       CO     NO2
--------------------------------------------------------------------------------
  1    2.3  455.5     537     3.4  .070    0.0      R       R        R       R
  2    3.8  325.5    2052     8.8  .060     .1    2.2  189.95  1197.4     5.1
  3    4.8  152.8    2152    17.0  .060     .4     .7   22.29   313.9     2.5
  4    5.6  143.0    2203    40.3  .050     .8     .4    9.26   142.6     2.6
  5    7.1  171.4    2316    85.5  .030     .6     .3    8.01   108.0     4.0
  6    6.6  195.0     288   551.4  .060    2.6     .2    4.55    18.4    12.9
  7   23.5   96.5     353   490.5 0.000    0.0     .4    1.50     5.5     7.6
  8   19.5   93.8     371   821.4  .040    2.8     .3    1.33     5.3    11.7
  9   22.7  348.9    6530   626.0 0.000    0.0     .3    4.43    82.8     7.9
 10   29.7  428.7    9739   543.5 0.000    0.0     .3    5.00   113.7     6.3
 11    4.0  268.5     637     3.7  .070    0.0      R       R        R       R
 12    4.2 1268.5     627     1.2  .120    0.0      R       R        R       R
 13   44.0  893.7   21237   665.7  .025    4.1     .3    5.52   131.1     4.1
 14   32.9  411.4   13648   913.5  .055    8.2     .2    2.76    91.7     6.1
 15   22.1  115.9    1799  1205.5  .035    4.6     .5     .87    13.6    12.9
 16   11.4  157.2    1274  1621.4  .060    7.3     .1    1.29    10.5    13.3
 17   13.2   81.2     423  1417.1  .060    4.9     .2    1.00     5.2    17.5
 18    7.1  158.0    1130   464.4 0.000    0.0     .2    3.90    27.9    11.5
 19    8.5  145.6    1291   300.8  .065    1.9     .3    4.99    44.3    10.3
 20   14.3  130.5    1560   138.7 0.000    0.0    1.1   10.07   120.3    10.7
 21    4.9  160.3    1920    70.6 0.000    0.0    1.5   49.46   592.4    21.8
 22    2.2  453.5     422     3.5  .080    0.0      R       R        R       R
 23    8.9 1498.3     457     1.4  .060    0.0      R       R        R       R

CYCLE COMPOSITE     HC      11.979     GRAM/BHP HR
                    CO      58.620     GRAM/BHP HR
                    NO2     10.494     GRAM/BHP HR
                    ALDE      .295     GRAM/BHP HR
                    BSFC      .675       LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-10-72 RUN 1                      ENGINE 1-2            STATIONARY DYNAMOMETER
---------------------------------------------------------------------------------------
                 DYNA.         MAN.   FUEL  RATE                  DRY CONCENTRATION
MODE SPEED       LOAD    HP    VAC. LB/HR   GM/HR    ALDE.     HC        CO      CO2       NO
---------------------------------------------------------------------------------------
   1   550        0.0     0   18.5    6.8    3071       32  18841      .930    10.78      40
   2  1200        7.5     2   20.2   12.4    5643       31   8146     2.480    11.72      75
   3  1200       30.0     7   19.3   14.1    6400       27   5077     2.140    11.72     122
   4  1200       67.6    15   17.5   16.2    7353       48   3072     1.660    11.01     280
   5  1200       93.9    21   16.4   18.1    8210       62   3064     1.450    10.89     475
   6  1200      187.5    43   11.5   23.9   10832       35   2494      .350    11.36    2000
   7  1200      281.0    64    3.0   33.9   15368       21    937      .100    11.01    1600
   8  1200      308.0    70    1.2   36.0   16339       76   1105      .100    11.24    1850
   9  1200      345.0    79    1.0   41.3   18720       40   3294     1.010    11.60    2100
  10  1200      375.0    86    0.0   46.9   21292       33   4387     2.730    10.78    1100
  11   550        0.0     0   18.5    6.8    3071       41  11003     1.200     9.64      47
  12  1200        0.0     0   22.5    6.3    2840       98  68331     1.090     4.45      14
  13  2300      370.0   162     .9   90.0   40824       57   4538     4.260    11.84     875
  14  2300      340.0   149    1.7   75.7   34347       90   1930      .970    13.63    2375
  15  2300      303.0   133    4.5   70.1   31784       90    786      .310    12.94    2400
  16  2300      278.0   122    5.5   62.2   28219       26    514      .180    12.47    2650
  17  2300      185.0    81   10.7   46.6   21133       41    642      .130    11.36    2850
  18  2300       92.5    41   16.2   33.6   15223       32   1381      .350    11.01    1450
  19  2300       66.6    29   17.4   30.1   13640       35   1497      .440    11.36     913
  20  2300       29.6    13   19.1   25.1   11394       51   1557      .670    11.48     475
  21  2300        7.4     3   20.4   22.3   10124       30   2507     1.120    11.24     250
  22   550        0.0     0   18.5    6.8    3071       71  17970      .700     8.93      40
  23  2300        0.0     0   24.7    7.1    3239       59  22490      .250     2.16       8
---------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO     NO2   FAC.       HP  ALDE.      HC       CO     NO2
---------------------------------------------------------------------------------------
   1   1.6  425.6     424     3.0   .070      0.0     R        R        R       R
   2   2.5  306.1    1883     9.4   .060       .1    1.5  178.65   1098.7     5.5
   3   2.6  226.2    1926    18.1   .060       .4     .4   32.99    280.9     2.6
   4   5.9  174.1    1900    52.7   .050       .8     .4   11.27    123.0     3.4
   5   8.8  198.9    1902   102.4   .030       .6     .4    9.27     88.6     4.8
   6   6.8  225.9     640   601.4   .060      2.6     .2    5.27     14.9    14.0
   7   6.2  128.6     222   728.6  0.000      0.0     .1    2.00      4.3    11.3
   8  23.3  157.7     288   876.4   .040      2.8     .3    2.24      4.1    12.5
   9  12.4  476.6    2952  1008.7  0.000      0.0     .2    6.05     37.4    12.8
  10  11.0  669.7    8418   557.5  0.000      0.0     .1    7.82     98.2     6.5
  11   2.3  283.0     623     4.0   .070      0.0     R        R        R       R
  12   4.9 1568.1     505     1.0   .120      0.0     R        R        R       R
  13  30.3 1119.2   21222   716.4   .025      4.1     .2    6.91    131.0     4.4
  14  45.1  448.0    4549  1830.8   .055      8.2     .3    3.01     30.6    12.3
  15  44.3  187.4    1493  1900.1   .035      4.6     .3    1.41     11.3    14.3
  16  12.4  114.2     808  1954.6   .060      7.3     .1     .94      6.6    16.1
  17  16.2  117.4     480  1730.7   .060      4.9     .2    1.45      5.9    21.4
  18   9.1  182.9     936   632.3  0.000      0.0     .2    4.51     23.1    15.7
  19   8.6  170.9    1015   345.8   .065      1.9     .3    5.86     34.8    11.9
  20  10.3  144.2    1253   146.0  0.000      0.0     .8   11.12     96.7    11.3
  21   5.3  201.3    1816    66.6  0.000      0.0    1.6   62.11    560.5    20.6
  22   4.1  482.9     380     3.6   .080      0.0     R        R        R       R
  23   8.9 1563.4     351     1.7   .060      0.0     R        R        R       R

CYCLE COMPOSITE      HC      13.613    GRAM/BHP HR
                     CO      41.614    GRAM/BHP HR
                     NO2     13.282    GRAM/BHP HR
                     ALDE      .289    GRAM/BHP HR
                     BSFC      .675      LB/BHP HR
```

```
                           PROJECT 11-2877-01  CONTROL TECHNOLOGY
    4-10-72 RUN 2                       ENGINE 1-2              STATIONARY DYNAMOMETER
------------------------------------------------------------------------------------------
                   DYNA.           MAN.    FUEL  RATE                  DRY CONCENTRATION
MODE SPEED         LOAD     HP     VAC.  LB/HR   GM/HR    ALDE.      HC       CO       CO2      NO
------------------------------------------------------------------------------------------
   1   550          0.0      0     18.5    6.8    3071       45   18878     .930     11.01      37
   2  1200          7.5      2     20.2   12.4    5643       35    7942    2.210     12.34      89
   3  1200         30.0      7     19.3   14.1    6400       32    4612    2.020     11.48     127
   4  1200         67.6     15     17.5   16.2    7353       31    3088    1.800     11.48     330
   5  1200         93.9     21     16.5   18.1    8210       39    3069    1.410     11.13     550
   6  1200        187.5     43     11.5   23.9   10832       36    2501     .350     11.72    2100
   7  1200        281.0     64      3.1   33.9   15368       40     656     .130      9.93    1800
   8  1200        308.0     70      1.2   36.0   16339       72     823     .130     10.43    2150
   9  1200        345.0     79      1.0   41.3   18720       45    2758     .610     10.55    2500
  10  1200        375.0     86      0.0   46.9   21292       57    3112    2.690      9.37    1050
  11   550          0.0      0     18.5    6.8    3071       50   11090    1.230     10.55      48
  12  1200          0.0      0     22.5    6.3    2840       79   56207     .930      4.54      12
  13  2300        370.0    162       .9   90.0   40824       44    3445    4.210     11.84     900
  14  2300        340.0    149      1.7   75.7   34347       80    1818    1.270     13.48    2350
  15  2300        303.0    133      4.5   70.1   31784       42     560     .250     12.82    2700
  16  2300        278.0    122      5.6   62.2   28218       25     678     .150     11.92    2900
  17  2300        185.0     81     10.7   46.6   21133       27     647     .130     11.24    3000
  18  2300         92.5     41     16.2   33.6   15223       42    1331     .310     11.48    1450
  19  2300         66.6     29     17.4   30.1   13640       63    1389     .420     11.60    1175
  20  2300         29.6     13     19.2   25.1   11394       27    1559     .670     11.60     575
  21  2300          7.4      3     20.4   22.3   10124       31    1791    1.050     11.84     300
  22   550          0.0      0     18.5    6.8    3071       42   13611     .580      9.03      43
  23  2300          0.0      0     24.7    7.1    3239       94   25613     .280      2.37       7
------------------------------------------------------------------------------------------
             CALCULATED GRAM/HR            WT.       WT.   BRAKE  SPECTFIC GRAM/BHP-HR
MODE ALDE.      HC        CO      NO2     FAC.       HP    ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
   1   2.2    419.2      417      2.7     .070      0.0       R        R        R        R
   2   2.8    292.1     1642     10.8     .060       .1     1.6   170.44    458.0      6.3
   3   3.2    211.4     1871     19.4     .060       .4      .5    30.85    272.9      2.8
   4   3.6    167.1     1967     59.3     .050       .8      .2    10.82    127.4      3.8
   5   5.3    196.1     1820    116.7     .030       .6      .2     9.14     84.8      5.4
   6   6.8    219.9      622    613.0     .060      2.6      .2     5.13     14.5     14.3
   7  13.0     99.5      399    907.0    0.000      0.0      .2     1.55      6.2     14.1
   8  23.7    126.4      403   1095.9     .040      2.8      .3     1.80      5.7     15.6
   9  16.1    451.5     2017   1358.7    0.000      0.0      .2     5.73     25.6     17.2
  10  21.1    535.7     9352    600.0    0.000      0.0      .2     6.25    109.1      7.0
  11   2.6    264.2      592      3.8     .070      0.0       R        R        R        R
  12   4.4   1439.1      481      1.0     .120      0.0       R        R        R        R
  13  23.4    857.9    21176    744.0     .025      4.1      .1     5.29    130.7      4.6
  14  39.5    418.3     5901   1794.6     .055      8.2      .3     2.81     39.6     12.1
  15  21.8    135.7     1223   2170.6     .035      4.6      .2     1.02      9.2     16.4
  16  12.4    157.6      704   2238.4     .060      7.3      .1     1.29      5.8     18.4
  17  10.9    119.5      485   1840.8     .060      4.9      .1     1.47      6.0     22.7
  18  11.6    169.9      800    614.6    0.000      0.0      .3     4.19     19.7     15.2
  19  15.3    155.8      952    437.6     .065      1.9      .5     5.34     32.6     15.0
  20   5.3    142.9     1241    175.1    0.000      0.0      .4    11.03     95.7     13.5
  21   5.3    138.7     1643     77.2    0.000      0.0     1.6    42.81    507.0     23.8
  22   2.6    381.0      328      3.9     .080      0.0       R        R        R        R
  23  12.6   1591.8      352      1.3     .060      0.0       R        R        R        R

CYCLE COMPOSITE     HC      12.680    GRAM/BHP HR
                    CO      42.415    GRAM/BHP HR
                    NO2     14.540    GRAM/BHP HR
                    ALDE      .256    GRAM/BHP HR
                    BSFC      .675      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-11-72 RUN 1                           ENGINE 1-2              STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------------------------
                    DYNA.            MAN.    FUEL  RATE                   DRY CONCENTRATION
MODE SPEED          LOAD     HP     VAC.  LB/HR   GM/HR      ALDE.      HC        CO        CO2      NO
-------------------------------------------------------------------------------------------------
   1   550          0.0       0     18.0    6.8    3071             0 18896    1.050     11.01      42
   2  1200          7.6       2     20.2   12.4    5643             0  6317    2.360     11.48      85
   3  1200         30.4       7     19.2   14.1    6400             0  3953    2.140     11.84     127
   4  1200         68.5      16     17.6   16.2    7353             0  3391    1.870     12.22     270
   5  1200         95.0      22     16.2   18.1    8210             0  3385    1.520     12.34     570
   6  1200        190.0      43     11.0   23.9   10832             0  2858     .350     12.71    2150
   7  1200        285.0      65      2.6   33.9   15368             0   776     .100     11.60    1700
   8  1200        312.0      71      2.2   36.0   16339             0  1114     .150     12.22    2150
   9  1200        350.0      80      2.1   41.3   18720             0  2705    1.270     12.47    2050
  10  1200        380.0      87      0.0   46.9   21292             0  3629    3.150     11.36     950
  11   550          0.0       0     18.0    6.8    3071             0 11133    1.120     11.13      48
  12  1200          0.0       0     22.9    6.3    2840             0 63291    1.090      4.84      13
  13  2300        370.0     162      1.9   90.0   40824             0  4137    4.400     11.72     850
  14  2300        340.0     149      2.7   75.7   34347             0  1931    1.050     13.63    2400
  15  2300        303.0     133      4.7   70.1   31784             0   848     .420     13.77    2600
  16  2300        278.0     122      5.8   62.2   28218             0   724     .310     13.91    2900
  17  2300        185.0      81     11.3   46.6   21133             0   579     .210     13.18    2800
  18  2300         92.5      41     16.3   33.6   15223             0  1338     .470     11.92    1400
  19  2300         66.6      29     17.7   30.1   13640             0  1505     .550     11.84    1000
  20  2300         29.6      13     19.2   25.1   11394             0  1562     .770     11.72     525
  21  2300          7.4       3     20.2   22.3   10124             0  2284    1.090     11.24     300
  22   550          0.0       0     18.4    6.8    3071             0 16478    1.010      9.64      48
  23  2300          0.0       0     24.7    7.1    3239             0 30705     .490      2.05       8
-------------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR              WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO      NO2    FAC.       HP   ALDE.      HC        CO      NO2
-------------------------------------------------------------------------------------------------
   1   0.0   416.0       467      3.1   .070      0.0      I         R         R        R
   2   0.0   246.3      1859     11.0   .060       .1    0.0    141.84    1070.5      6.3
   3   0.0   176.0      1925     18.8   .060       .4    0.0     25.34     277.1      2.7
   4   0.0   172.8      1925     45.7   .050       .8    0.0     11.04     123.0      2.9
   5   0.0   195.7      1775    109.4   .030       .7    0.0      9.02      81.8      5.0
   6   0.0   232.0       574    579.3   .060      2.6    0.0      5.34      13.2     13.3
   7   0.0   101.2       264    736.5  0.000      0.0    0.0      1.55       4.0     11.3
   8   0.0   145.9       397    934.4   .040      2.9    0.0      2.05       5.6     13.1
   9   0.0   361.4      3428    909.4  0.000      0.0    0.0      4.52      42.9     11.4
  10   0.0   514.6      9109    451.5  0.000      0.0    0.0      5.98     104.9      5.2
  11   0.0   255.8       520      3.6   .070      0.0      I         R         R        R
  12   0.0  1466.0       510      1.0   .120      0.0      I         R         R        R
  13   0.0  1021.4     21946    696.8   .025      4.1    0.0      6.30     135.4      4.3
  14   0.0   445.9      4898   1840.1   .055      8.2    0.0      2.99      32.9     12.4
  15   0.0   188.9      1889   1922.0   .035      4.6    0.0      1.42      14.2     14.5
  16   0.0   143.0      1236   1900.9   .060      7.3    0.0      1.17      10.2     15.6
  17   0.0    91.0       667   1460.9   .060      4.9    0.0      1.12       8.2     18.0
  18   0.0   162.6      1154    565.0  0.000      0.0    0.0      4.01      28.5     13.9
  19   0.0   163.7      1208    361.1   .065      1.9    0.0      5.61      41.4     12.4
  20   0.0   140.7      1401    157.0  0.000      0.0    0.0     10.86     108.1     12.1
  21   0.0   184.1      1775     80.3  0.000      0.0    0.0     56.81     547.7     24.8
  22   0.0   411.5       509      4.0   .080      0.0      I         R         R        R
  23   0.0  1772.5       571      1.4   .060      0.0      I         R         R        R

CYCLE COMPOSITE     HC      13.118    GRAM/BHP HR
                    CO      44.556    GRAM/BHP HR
                    NO2     12.815    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .674      LB/BHP HR
```

APPENDIX D

EMISSION RESULTS FROM ENGINE 2-2

TABULAR FORM

ENGINE 2-2

NINE MODE FTP EMISSION RESULTS

CONCENTRATION BASIS

```
 4-14-72         ENGINE 2-2      RUN 2                                        K =1.120      HUM = 116  GR/LB
 ------------------------------------------------------------------------------------------------------------------
 FEDERAL         CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D    WEIGHTING         W E I G H T E D
 MODE              HC      CO     CO2      NO    FACTOR       HC      CO     NO     FACTOR          HC       CO        NO
 ------------------------------------------------------------------------------------------------------------------
CYCLE 1
 1 IDLE           179   1.050  13.060      84     1.052      188   1.105     88      .036        6.782    .040     3.182
 2 16'HG           80   1.480  13.060     384     1.044       84   1.545    401      .089        7.435    .138    35.686
 3 10'HG           80   1.090  13.180    1206     1.050       84   1.144   1266      .257       21.585    .294   325.395
 4 16'HG           61   1.300  13.180     420     1.043       64   1.357    438      .089        5.665    .121    39.005
 5 19'HG           18    .250  13.440     157     1.067       19    .267    168      .047         .903    .013     7.876
 6 16'HG           57   1.300  13.180     435     1.044       59   1.357    454      .089        5.295    .121    40.411
 7  3'HG          102   1.230  13.060    1904     1.052      107   1.294   2003      .283       30.363    .366   566.774
 8 16'HG           58   1.450  13.060     420     1.047       61   1.518    440      .084        5.405    .135    39.141
 9 C.T.          1741    .882   5.750      73     1.796     3128   1.585    131      .021       65.682    .033     2.754
 SUM------------(CYCLE COMPOSITE)-------------------------------------------------------     149.114   1.260  1060.224
CYCLE 2
 1 IDLE           166   1.010  12.820      90     1.074      178   1.084     97      .036        6.417    .039     3.479
 2 16'HG           75   1.410  12.470     406     1.094       82   1.542    444      .084        7.301    .137    39.525
 3 10'HG           80   1.120  12.590    1259     1.095       88   1.227   1379      .257       22.523    .315   354.452
 4 16'HG           35   1.380  12.690     435     1.081       38   1.491    470      .089        3.366    .133    41.838
 5 19'HG            9    .250  12.940     183     1.109       10    .277    203      .047         .469    .013     9.539
 6 16'HG           53   1.450  12.470     449     1.094       58   1.587    491      .089        5.161    .141    43.724
 7  3'HG          107   1.630  12.470    1800     1.082      116   1.764   1948      .283       32.765    .449   551.193
 8 16'HG           62   1.590  12.340     449     1.098       68   1.746    493      .089        6.061    .155    43.890
 9 C.T.          1857    .948   5.960     111     1.718     3191   1.629    191      .021       67.001    .034     4.005
 SUM------------(CYCLE COMPOSITE)-------------------------------------------------------     151.064   1.467  1091.643
CYCLE 3
 1 IDLE           180    .970  12.710     143     1.083      195   1.050    155      .036        7.017    .038     5.575
 2 16'HG           86   1.590  12.590     449     1.076       93   1.711    483      .089        8.234    .152    42.992
 3 10'HG           93   1.200  12.710    1351     1.081      101   1.297   1461      .257       25.843    .333   375.417
 4 16'HG           73   1.520  12.590     493     1.080       79   1.641    532      .089        7.015    .146    47.377
 5 19'HG           26    .250  13.060     250     1.097       29    .274    274      .047        1.341    .013    12.894
 6 16'HG           66   1.550  12.590     508     1.079       71   1.673    548      .089        6.339    .149    48.791
 7  3'HG          118   1.380  12.470    1447     1.091      129   1.506   2125      .283       36.441    .426   601.283
 8 16'HG           79   1.470  12.590     538     1.081       85   1.589    582      .089        7.602    .141    51.773
 9 C.T.          1853    .803   5.750     168     1.779     3296   1.428    299      .021       69.208    .030     6.275
 SUM------------(CYCLE COMPOSITE)-------------------------------------------------------     169.042   1.429  1192.376
CYCLE 4
 1 IDLE           180    .610  12.590     210     1.099      198    .890    231      .036        7.124    .032     8.311
 2 16'HG           92   1.520  12.590     523     1.078       99   1.639    564      .089        8.828    .146    50.183
 3 10'HG           91   1.270  12.590    1369     1.088       99   1.382   1490      .257       25.453    .355   382.907
 4 16'HG           71   1.590  12.470     552     1.087       77   1.728    600      .089        6.868    .154    53.393
 5 19'HG           22    .250  12.820     320     1.118       25    .280    358      .047        1.156    .013    16.816
 6 16'HG           62   1.520  12.290     552     1.105       69   1.680    610      .089        6.100    .150    54.308
 7  3'HG          114   1.410  12.230    1989     1.110      127   1.566   2209      .283       35.824    .443   625.041
 8 16'HG           71   1.520  12.220     582     1.111       79   1.688    646      .089        7.018    .150    57.524
 9 C.T.          1773    .770   5.500     217     1.859     3296   1.431    403      .021       69.217    .030     8.472
 SUM------------(CYCLE COMPOSITE)-------------------------------------------------------     167.586   1.473  1256.955

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------------------     150.089   1.364  1075.934

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------------     168.314   1.451  1224.666

 FOUR CYCLE COMPOSITE - REPORTED VALUES -     HC    0.35*(  150.089) + 0.65*(  168.314) =   161.935  PPM
                                              CO    0.35*(    1.364) + 0.65*(    1.451) =     1.420  PERCENT
                                              NO    0.35*( 1075.934) + 0.65*( 1224.666) =  1172.610  PPM
                                                                          CORRECTED NO =  1313.340  PPM

 DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
 4-14-72      ENGINE [illegible]      RUN [illegible]                          K =1.111     HUM = 112  GR/LB
------------------------------------------------------------------------------------------------------------------
 FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D    WEIGHTING        W E I G H T E D
 MODE           HC      CO     CO2     NO      FACTOR     HC     CO     NO      FACTOR       HC       CO        NO
------------------------------------------------------------------------------------------------------------------
CYCLE 1
 1 IDLE         184    .815  13.180    112     1.052     194   .857    123     .036        6.967    .031     4.430
 2 16'HG         98   1.451  14.180    420     1.035     101  1.561    435     .089        9.027    .134    38.685
 3 10'HG        102   1.160  14.480   1314     1.023     104  1.187   1345     .257       26.824    .305   345.559
 4 16'HG         84   1.450  13.330    478     1.025      86  1.486    490     .089        7.663    .132    43.607
 5 19'HG         35    .255  13.770    197     1.041      36   .265    205     .047        1.712    .012     9.634
 6 16'HG         80   1.420  13.180    493     1.034      83  1.571    510     .089        7.360    .140    45.359
 7  3'HG        125   1.410  13.180   1947     1.034     129  1.458   2014     .283       36.586    .413   569.866
 8 16'HG         84   1.480  13.180    493     1.035      87  1.532    510     .089        7.737    .136    45.409
 9 C.T.        1841    .763   6.820     80     1.569    2967  1.192    126     .021       62.302    .025     2.636
 SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    166.178   1.328  1105.184
CYCLE 2
 1 IDLE         180    .615  13.060    183     1.061     191   .865    194     .036        6.878    .031     6.992
 2 16'HG         89   1.590  12.940    493     1.048      93  1.667    517     .089        8.304    .148    45.999
 3 10'HG         89   1.160  13.100   1387     1.053      94  1.221   1460     .257       24.075    .314   375.189
 4 16'HG         75   1.520  12.940    538     1.052      79  1.599    566     .089        7.023    .142    50.380
 5 19'HG         31    .250  13.480    307     1.063      33   .266    326     .047        1.549    .012    15.340
 6 16'HG         80   1.539  12.940    538     1.051      84  1.618    565     .089        7.483    .144    50.326
 7  3'HG        116   1.450  12.820   1968     1.061     123  1.538   2087     .283       34.821    .435   590.748
 8 16'HG         75   1.660  12.820    552     1.056      79  1.753    583     .089        7.049    .156    51.879
 9 C.T.        1719    .660   6.300    116     1.709    2937  1.128    198     .021       61.678    .024     4.162
 SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    158.860   1.407  1191.016
CYCLE 3
 1 IDLE         180    .740  13.060    265     1.064     192   .788    282     .036        6.896    .028    10.153
 2 16'HG         93   1.737  12.710    552     1.060      99  1.841    585     .089        8.774    .154    52.077
 3 10'HG         95   1.230  12.940   1407     1.062     101  1.306   1494     .257       25.921    .336   383.902
 4 16'HG         75   1.590  12.820    598     1.059      79  1.683    633     .089        7.067    .150    56.346
 5 19'HG         31    .280  13.330    363     1.074      33   .301    390     .047        1.565    .014    18.320
 6 16'HG         75   1.630  12.820    613     1.057      79  1.723    648     .089        7.057    .153    57.675
 7  3'HG        116   1.450  12.940   2055     1.051     122  1.525   2161     .283       34.518    .431   611.495
 8 16'HG         80   1.585  13.060    659     1.040      83  1.649    686     .089        7.407    .147    61.012
 9 C.T.        1841    .930   6.130    129     1.689    3110  1.571    218     .021       65.311    .033     4.576
 SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    164.514   1.456  1255.558
CYCLE 4
 1 IDLE         184    .640  13.330    302     1.047     193   .670    321     .036        6.936    .024    11.572
 2 16'HG         98   1.640  12.820    613     1.047     103  1.927    642     .089        9.134    .171    57.135
 3 10'HG        102   1.230  13.060   1463     1.052     107  1.294   1539     .257       27.573    .333   395.488
 4 16'HG         84   1.700  12.710    613     1.062      89  1.806    651     .089        7.941    .161    57.951
 5 19'HG         31    .280  13.330    406     1.074      33   .301    436     .047        1.565    .014    20.490
 6 16'HG         71   1.630  12.710    628     1.066      76  1.738    669     .089        6.736    .155    59.583
 7  3'HG        116   1.450  12.710   2033     1.069     124  1.550   2174     .283       35.103    .439   615.210
 8 16'HG         80   1.630  12.710    659     1.065      85  1.736    702     .089        7.585    .155    62.480
 9 C.T.        1833    .700   6.470    136     1.648    3020  1.153    224     .021       63.429    .024     4.706
 SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    166.001   1.475  1284.615

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------    162.519   1.368  1148.100

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------    165.258   1.466  1270.087

 FOUR CYCLE COMPOSITE - REPORTED VALUES =     HC    0.35*(  162.519) + 0.65*(  165.258) =   164.299  PPM
                                              CO    0.35*(    1.368) + 0.65*(    1.466) =     1.431  PERCENT
                                              NO    0.35*( 1148.100) + 0.65*( 1270.087) =  1227.391  PPM
                                                                        CORRECTED NO =  1363.516  PPM

 DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
4-14-76      [illegible]                                        H = 31.[illegible]    NOX = 1[illegible]6 GR/LB
-------------------------------------------------------------------------------------------------------------------------
FEDERAL     CONCENTRATION AS MEASURED    DILUTION     C O R R E C T E D   WEIGHTING      W E I G H T E D
MODE         HC     CO     CO2     NO     FACTOR       HC     CO     NO    FACTOR        HC       CO       NO
-------------------------------------------------------------------------------------------------------------------------
CYCLE 1
  1 IDLE    147   .590  [illegible]  40   1.031      [illegible] .606   43    .036       6.678    .018     3.339
  2 16"HG    40  1.230  13.910   444       .942       40  1.220  445    .089       7.443    .109    40.951
  3 10"HG    69   .940  13.910  1444      1.002       69   .942 1447    .257      22.919    .234   371.849
  4 16"HG    71  1.240  13.410   504       .993       71  1.221  504    .089       6.275    .109    44.847
  5 19"HG    27   .210  14.180   213      1.013       27   .213  213    .047       1.265    .010     9.998
  6 16"HG    66  1.220  13.910   443       .992       65  1.210  444    .089       5.827    .112    43.528
  7  3"HG   120  1.410  13.630  2011      1.002      120  1.413 2016    .283      34.043    .400   570.506
  8 16"HG    75  1.520  14.220   508       .992       74  1.508  504    .089       6.624    .134    44.869
  9 C.T.   1806   .640   5.340   125      1.893     3418  1.211  237    .021      71.788    .025     4.969
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------    163.383   1.157  1134.905
CYCLE 2
  1 IDLE    141  1.050  13.480   130      1.020      145  1.071  133    .036       7.016    .039     4.775
  2 16"HG    97  1.550  14.480   449      1.010       98  1.565  453    .089       8.717    .139    40.351
  3 10"HG   198  1.160  14.480  1444      1.016      201  1.178 1467    .257      51.642    .303   376.988
  4 16"HG    60  1.520  13.480   443      1.012       61  1.538  449    .089       7.206    .137    44.409
  5 19"HG    31   .282  14.050   251      1.019       32   .287  256    .047       1.485    .014    12.026
  6 16"HG    75  1.480  13.330   443      1.025       77  1.517  505    .064       6.840    .135    44.954
  7  3"HG   125  1.840  13.180  1865      1.014      127  1.874 1900    .283      36.034    .530   537.620
  8 16"HG    85  1.660  13.330   525      1.017       86  1.689  533    .089       7.697    .150    47.448
  9 C.T.   1768   .620   5.220   164      1.804     3199  1.212  340    .021      67.173    .025     7.143
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------    193.860   1.472  1115.719
CYCLE 3
  1 IDLE    175   .970  13.180   143      1.047      183  1.015  150    .036       6.594    .037     5.389
  2 16"HG    93  1.720  12.940   464      1.041       97  1.793  483    .089       8.619    .164    43.000
  3 10"HG    89  1.340  13.060  1389      1.049       93  1.405 1456    .257      23.988    .361   374.102
  4 16"HG    75  1.630  12.940   523      1.048       79  1.708  548    .089       6.995    .152    48.781
  5 19"HG    31   .300  13.630   265      1.050       33   .315  278    .047       1.529    .015    13.074
  6 16"HG    71  1.700  12.940   523      1.046       74  1.778  547    .089       6.508    .158    48.673
  7  3"HG   115  1.590  13.180  1947      1.028      118  1.635 2002    .283      33.759    .463   566.621
  8 16"HG    80  1.700  13.180   508      1.027       82  1.746  522    .089       7.313    .155    46.441
  9 C.T.   1788   .610   5.640   257      1.841     3292  1.123  473    .021      69.127    .024     9.936
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------    154.531   1.529  1156.015
CYCLE 4
  1 IDLE    170   .720  13.180   170      1.055      179   .812  179    .036       6.454    .029     6.454
  2 16"HG    93  1.660  12.940   493      1.045       97  1.735  515    .089       8.653    .154    45.869
  3 10"HG    93  1.200  14.050  1482      1.054       98  1.264 1562    .257      25.186    .325   401.344
  4 16"HG    80  1.550  12.940   552      1.051       84  1.628  580    .089       7.480    .145    51.615
  5 19"HG    31   .250  13.480   229      1.063       33   .266  247    .047       1.549    .012    13.941
  6 16"HG    75  1.550  12.940   552      1.051       79  1.629  580    .089       7.016    .145    51.635
  7  3"HG   120  1.520  12.820  2055      1.058      127  1.608 2173    .283      35.918    .455   615.094
  8 16"HG    84  1.640  12.540   598      1.047       88  1.707  626    .089       7.829    .152    55.737
  9 C.T.   1740   .520   5.260   273      1.838     3198   .956  502    .021      67.159    .020    10.537
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------    167.244   1.438  1252.226

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------    178.621   1.315  1125.312

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------    165.868   1.483  1204.121

  FOUR CYCLE COMPOSITE = REPORTED VALUES =   HC    0.35*(  178.621) + 0.65*(  165.888) =   170.344  PPM
                                             CO    0.35*(    1.315) + 0.65*(    1.443) =     1.424  PERCENT
                                             NO    0.35*( 1125.312) + 0.65*( 1204.121) =  1176.538  PPM
                                                                       CORRECTED NO =  1289.705  PPM

  DILUTION FACTOR = 14.5/(CO2+.5*CO +10.[illegible]HC)
```

ENGINE 2-2

NINE MODE FTP EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
4-14-72         ENGINE 2-2     RUN 2                                        K = 1.09      HUM = 116  GR/LB
------------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED       TOTAL     FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
MODE            HC      CO      CO2     NO    CARBON    CONS.      HC      CO    NO2    FACT.      HC      CO   NO2(K)  HP
------------------------------------------------------------------------------------------------------------------

CYCLE 1
        1 IDLE      179   1.050   13.06     84   14.303     2633      36     390      5   .232      8.3      91     1.2    0
        2 16 HG      80   1.480   13.06    384   14.626    11672      69    2386    102   .077      5.3     184     7.8   24
        3 10 HG      80   1.090   13.18   1206   14.356    17806     107    2731    497   .147     15.8     401    73.0   62
        4 16 HG      61   1.300   13.18    420   14.546    11672      53    2107    112   .077      4.1     162     8.6   24
        5 19 HG      18    .250   13.44    157   13.709     8749      12     322     33   .057       .7      18     1.9    3
        6 16 HG      57   1.300   13.18    435   14.542    11672      49    2108    116   .077      3.8     162     8.9   24
        7  3 HG     102   1.230   13.06   1904   14.400    24970     191    4308   1096   .113     21.6     487   123.9  103
        8 16 HG      58   1.450   13.06    420   14.573    11672      50    2346    112   .077      3.9     181     8.6   24
        9 C.T.     1741    .882    5.75     73    8.512     2706     598     566      8   .143     85.5      81     1.1    0
        SUM------------(CYCLE COMPOSITE)--------------------------------------------------      5.2      62     8.3

CYCLE 2
        1 IDLE      166   1.010   12.82     90   14.009     2633      34     383      6   .232      7.8      89     1.3    0
        2 16 HG      75   1.410   12.47    406   13.961    11672      68    2381    113   .077      5.2     183     8.7   24
        3 10 HG      80   1.120   12.59   1259   13.796    17806     112    2920    539   .147     16.4     429    79.3   62
        4 16 HG      35   1.380   12.69    435   14.108    11672      31    2306    119   .077      2.4     178     9.2   24
        5 19 HG       9    .250   12.94    183   13.200     8749       6     335     40   .057       .4      19     2.3    3
        6 16 HG      53   1.450   12.47    449   13.977    11672      48    2446    124   .077      3.7     188     9.6   24
        7  3 HG     107   1.630   12.47   1800   14.216    24970     203    5784   1050   .113     22.9     654   118.6  103
        8 16 HG      62   1.590   12.34    449   13.997    11672      56    2678    124   .077      4.3     206     9.6   24
        9 C.T.     1857    .948    5.96    111    8.914     2706     609     581     11   .143     87.1      83     1.6    0
        SUM------------(CYCLE COMPOSITE)--------------------------------------------------      5.3      72     8.5

CYCLE 3
        1 IDLE      180    .970   12.71    143   13.874     2633      37     372      9   .232      8.6      86     2.1    0
        2 16 HG      86   1.590   12.59    449   14.273    11672      76    2627    122   .077      5.8     202     9.4   24
        3 10 HG      93   1.200   12.71   1351   14.010    17806     128    3081    570   .147     18.8     453    83.8   62
        4 16 HG      73   1.520   12.59    493   14.189    11672      65    2526    135   .077      5.0     194    10.4   24
        5 19 HG      26    .250   13.06    250   13.338     8749      18     331     54   .057      1.0      19     3.1    3
        6 16 HG      66   1.550   12.59    508   14.211    11672      59    2572    139   .077      4.5     198    10.7   24
        7  3 HG     118   1.380   12.47   1947   13.977    24970     228    4980   1155   .113     25.7     563   130.5  103
        8 16 HG      79   1.470   12.59    538   14.145    11672      70    2450    147   .077      5.4     189    11.3   24
        9 C.T.     1853    .803    5.75    168    8.554     2706     633     513     18   .143     90.5      73     2.5    0
        SUM------------(CYCLE COMPOSITE)--------------------------------------------------      5.8      70     9.3

CYCLE 4
        1 IDLE      180    .810   12.59    210   13.594     2633      38     317     14   .232      8.7      74     3.1    0
        2 16 HG      92   1.520   12.59    523   14.209    11672      82    2522    143   .077      6.3     194    11.0   24
        3 10 HG      91   1.270   12.59   1369   13.958    17806     125    3273    580   .147     18.4     481    85.2   62
        4 16 HG      71   1.590   12.47    552   14.137    11672      63    2652    151   .077      4.9     204    11.7   24
        5 19 HG      22    .250   12.82    320   13.094     8749      16     337     71   .057       .9      19     4.0    3
        6 16 HG      62   1.520   12.29    552   13.877    11672      56    2583    154   .077      4.3     199    11.9   24
        7  3 HG     114   1.410   12.23   1999   13.763    24970     223    5167   1198   .113     25.2     584   135.4  103
        8 16 HG      71   1.520   12.22    592   13.817    11672      65    2594    163   .077      5.0     200    12.6   24
        9 C.T.     1773    .770    5.50    217    8.185     2706     633     514     24   .143     90.5      74     3.4    0
        SUM--------- --(CYCLE COMPOSITE)--------------------------------------------------      5.8      72     9.8

        AVERAGE S ----(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------      5.3      67     8.4

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------      5.8      71     9.6

        FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(      5.3) + 0.65(      5.8) =     5.622  (MASS)
                                                 CO  0.35(       67) + 0.65(       71) =      69.3  (MASS)
                                                 NO2 0.35(      8.4) + 0.65(      9.6) =     9.142  (MASS)
                                                                    CORRECTED NO2 =    10.001  (MASS)
```

```
         4-14-72       ENGINE 2-2        RUN 3                                   K = 1.09      HUM = 112  GR/LB
         ------------------------------------------------------------------------------------------------------------
         MASS          CONCENTRATION AS MEASURED     TOTAL     FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
         MODE           HC      CO      CO2     NO   CARBON    CONS.      HC      CO    NO2    FACT.      HC      CO   NO2(K)  HP
         ------------------------------------------------------------------------------------------------------------

CYCLE 1
         1 IDLE         184     .815   13.18    117   14.194     2633      37     305      7    .232      8.6      71     1.7    0
         2 16 HG         98    1.450   13.18    420   14.736    11672      84    2320    110    .077      6.5     179     8.5   24
         3 10 HG        102    1.160   13.48   1314   14.750    17806     133    2829    527    .147     19.5     416    77.4   62
         4 16 HG         84    1.450   13.33    428   14.871    11672      71    2299    125    .077      5.5     177     9.6   24
         5 19 HG         35     .255   13.77    192   14.063     8749      24     320     41    .057      1.3      18     2.3    3
         6 16 HG         80    1.520   13.18    493   14.786    11672      68    2424    129    .077      5.3     187     9.9   24
         7  3 HG        125    1.410   13.18   1447   14.725    24970     229    4830   1096    .113     25.9     546   123.9  103
         8 16 HG         84    1.480   13.18    493   14.751    11672      72    2366    130    .077      5.5     182    10.0   24
         9 C.T.        1891     .760    6.82     80    9.622     2706     574     432      7    .143     82.1      62     1.1    0
         SUM------------(CYCLE COMPOSITE)-------------------------------------------------------      5.6      65     8.6

CYCLE 2
         1 IDLE         180     .815   13.06    183   14.069     2633      36     308     11    .232      8.4      71     2.6    0
         2 16 HG         89    1.590   12.94    493   14.626    11672      77    2563    131    .077      5.9     197    10.1   24
         3 10 HG         89    1.160   13.10   1387   14.356    17806     119    2906    571    .147     17.5     427    84.0   62
         4 16 HG         75    1.520   12.94    538   14.541    11672      65    2465    143    .077      5.0     190    11.0   24
         5 19 HG         31     .250   13.48    307   13.763     8749      21     321     65    .057      1.2      18     3.7    3
         6 16 HG         80    1.539   12.94    538   14.565    11672      69    2491    143    .077      5.3     192    11.0   24
         7  3 HG        116    1.450   12.82   1968   14.395    24970     217    5081   1133    .113     24.6     574   128.1  103
         8 16 HG         75    1.660   12.82    552   14.561    11672      65    2688    147    .077      5.0     207    11.3   24
         9 C.T.        1719     .660    6.30    116    8.817     2706     570     409     12    .143     81.5      59     1.7    0
         SUM------------(CYCLE COMPOSITE)-------------------------------------------------------      5.4      68     9.3

CYCLE 3
         1 IDLE         180     .740   13.06    265   13.994     2633      37     281     17    .232      8.5      65     3.8    0
         2 16 HG         93    1.737   12.71    552   14.547    11672      81    2815    147    .077      6.2     217    11.3   24
         3 10 HG         95    1.230   12.94   1407   14.273    17806     128    3100    583    .147     18.8     456    85.7   62
         4 16 HG         75    1.590   12.82    598   14.491    11672      65    2587    160    .077      5.0     199    12.3   24
         5 19 HG         31     .280   13.33    363   13.643     8749      21     363     77    .057      1.2      21     4.4    3
         6 16 HG         75    1.630   12.82    613   14.531    11672      65    2645    163    .077      5.0     204    12.6   24
         7  3 HG        116    1.450   12.94   2055   14.515    24970     216    5039   1174    .113     24.4     569   132.6  103
         8 16 HG         80    1.585   13.06    659   14.731    11672      68    2537    173    .077      5.3     195    13.3   24
         9 C.T.        1841     .930    6.13    129    9.048     2706     595     562     13    .143     85.0      80     1.8    0
         SUM------------(CYCLE COMPOSITE)-------------------------------------------------------      5.6      71     9.8

CYCLE 4
         1 IDLE         184     .640   13.33    307   14.169     2633      37     240     19    .232      8.6      56     4.4    0
         2 16 HG         98    1.840   12.82    613   14.766    11672      84    2938    161    .077      6.4     226    12.4   24
         3 10 HG        102    1.230   13.06   1463   14.400    17806     136    3072    601    .147     20.0     452    88.3   62
         4 16 HG         84    1.700   12.71    613   14.501    11672      73    2764    164    .077      5.6     213    12.6   24
         5 19 HG         31     .280   13.33    406   13.643     8749      21     363     86    .057      1.2      21     4.9    3
         6 16 HG         71    1.630   12.71    628   14.417    11672      62    2666    169    .077      4.8     205    13.0   24
         7  3 HG        116    1.450   12.71   2033   14.285    24970     219    5120   1180    .113     24.7     579   133.3  103
         8 16 HG         80    1.630   12.71    659   14.426    11672      70    2664    177    .077      5.4     205    13.6   24
         9 C.T.        1833     .700    6.47    136    9.150     2706     585     418     13    .143     83.7      60     1.9    0
         SUM------------(CYCLE COMPOSITE)-------------------------------------------------------      5.7      71    10.0

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------------------      5.5      66     9.0

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------------      5.6      71     9.9

         FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     5.5) + 0.65(     5.6) =    5.606  (MASS)
                                                  CO  0.35(      66) + 0.65(      71) =     69.4  (MASS)
                                                  NO2 0.35(     9.0) + 0.65(     9.9) =    9.577  (MASS)
                                                                 CORRECTED NO2 =   10.420  (MASS)
```

```
4-14-72        ENGINE 2-2        RUN 4                                       K = 1.04      HUM = 106  GR/LB
---------------------------------------------------------------------------------------------------------------
MASS         CONCENTRATION AS MEASURED     TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
MODE          HC     CO     CO2     NO    CARBON   CONS.      HC      CO     NO2    FACT.      HC      CO   NO2(K)   HP
---------------------------------------------------------------------------------------------------------------

CYCLE 1
     1 IDLE       180   .490  13.63     90   14.314    2633      36     182      5   .232      8.3      42     1.3     0
     2 16 HG       90  1.230  13.91    464   15.237   11672      74    1903    118   .077      5.7     147     9.1    24
     3 10 HG       89   .930  13.91   1444   14.936   17806     115    2240    572   .147     16.8     329    84.0    62
     4 16 HG       71  1.230  13.91    508   15.217   11672      59    1906    129   .077      4.5     147    10.0    24
     5 19 HG       27   .210  14.18    210   14.419    8749      19     257     42   .057      1.0      15     2.4     3
     6 16 HG       66  1.220  13.91    493   15.251   11672      55    1963    125   .077      4.2     151     9.6    24
     7  3 HG      120  1.410  13.63   2011   15.170   24970     213    4688   1099   .113     24.1     530   124.2   103
     8 16 HG       75  1.520  13.72    508   15.321   11672      62    2332    128   .077      4.7     180     9.9    24
     9 C.T.      1806   .640   5.39    125    7.980    2706     661     438     14   .143     94.6      63     2.0     0
     SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      5.8      56     8.9

CYCLE 2
     1 IDLE       191  1.050  13.48    130   14.736    2633      37     379      8   .232      8.6      88     1.8     0
     2 16 HG       97  1.550  13.48    449   15.135   11672      81    2415    115   .077      6.2     186     8.9    24
     3 10 HG      198  1.160  13.48   1444   14.854   17806     256    2809    575   .147     37.7     413    84.5    62
     4 16 HG       80  1.520  13.48    493   15.086   11672      67    2376    127   .077      5.1     183     9.8    24
     5 19 HG       31   .282  14.05    251   14.365    8749      20     347     51   .057      1.2      20     2.9     3
     6 16 HG       75  1.480  13.33    493   14.891   11672      63    2343    128   .077      4.9     180     9.9    24
     7  3 HG      125  1.940  13.18   1865   15.155   24970     222    6124   1020   .113     25.1     692   115.3   103
     8 16 HG       85  1.660  13.33    524   15.082   11672      71    2595    135   .077      5.5     200    10.4    24
     9 C.T.      1768   .670   5.77    188    8.349    2706     619     439     20   .143     88.5      63     2.8     0
     SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      6.4      71     8.7

CYCLE 3
     1 IDLE       175   .970  13.18    143   14.339    2633      35     360      9   .232      8.1      83     2.0     0
     2 16 HG       93  1.770  12.94    464   14.810   11672      79    2818    121   .077      6.1     217     9.3    24
     3 10 HG       89  1.340  13.06   1389   14.496   17806     118    3325    566   .147     17.4     489    83.2    62
     4 16 HG       75  1.630  12.94    523   14.651   11672      65    2623    138   .077      5.0     202    10.7    24
     5 19 HG       31   .300  13.63    265   13.963    8749      21     380     55   .057      1.2      22     3.1     3
     6 16 HG       71  1.700  12.94    523   14.717   11672      61    2724    138   .077      4.7     210    10.6    24
     7  3 HG      116  1.590  13.18   1947   14.895   24970     210    5384   1084   .113     23.7     608   122.4   103
     8 16 HG       80  1.700  13.18    508   14.966   11672      67    2678    132   .077      5.2     206    10.1    24
     9 C.T.      1788   .610   5.64    257    8.181    2706     639     408     28   .143     91.3      58     4.0     0
     SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      5.7      74     9.0

CYCLE 4
     1 IDLE       170   .770  13.18    170   14.134    2633      34     290     11   .232      7.9      67     2.4     0
     2 16 HG       93  1.660  12.94    493   14.700   11672      80    2662    130   .077      6.1     205    10.0    24
     3 10 HG       93  1.200  13.06   1482   14.360   17806     125    3006    610   .147     18.3     442    89.7    62
     4 16 HG       80  1.550  12.94    552   14.576   11672      69    2507    147   .077      5.3     193    11.3    24
     5 19 HG       31   .250  13.48    279   13.763    8749      21     321     59   .057      1.2      18     3.4     3
     6 16 HG       75  1.550  12.94    552   14.571   11672      65    2508    147   .077      5.0     193    11.3    24
     7  3 HG      120  1.520  12.82   2055   14.470   24970     224    5299   1177   .113     25.3     594   133.0   103
     8 16 HG       84  1.630  12.94    598   14.661   11672      72    2621    158   .077      5.6     202    12.2    24
     9 C.T.      1740   .520   5.75    273    8.149    2706     624     349     30   .143     89.2      50     4.3     0
     SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      5.8      69     9.8

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------------      6.1      64     8.8

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------      5.8      72     9.4

     FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(      6.1) + 0.65(      5.8) =    5.881  (MASS)
                                              CO  0.35(       64) + 0.65(       72) =     68.9  (MASS)
                                              NO2 0.35(      8.8) + 0.65(      9.4) =    9.185  (MASS)
                                                              CORRECTED NO2 =    9.900  (MASS)
```

ENGINE 2-2

EXPERIMENTAL 23 MODE EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-17-72 RUN 1                    ENGINE 2-2          STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------
                DYNA.         MAN.   FUEL  RATE              DRY CONCENTRATION
MODE SPEED      LOAD    HP   VAC. LB/HR  GM/HR    ALDE.     HC      CO      CO2     NO
-------------------------------------------------------------------------------
  1   550        0.0     0   17.5   5.8    2631      40   3709    .740   14.53     44
  2  1200        5.2     1   17.7  11.7    5289      18    187    .050   14.05     80
  3  1200       20.8     5   16.8  14.1    6378      21    261    .150   14.42    152
  4  1200       46.8    11   15.3  15.4    6981      32    626    .180   14.79    295
  5  1200       65.0    15   14.5  17.1    7775      65    707    .150   15.09    500
  6  1200      130.0    30   12.3  22.4   10170      23   2089    .520   15.43   1100
  7  1200      195.0    45    7.0  27.2   12329      31   2982    .810   15.09   1775
  8  1200      213.0    49    5.8  30.0   13608      35   3073    .930   14.94   1875
  9  1200      239.0    55    3.4  32.1   14579      43   2863   1.050   14.66   2000
 10  1200      260.0    59    0.0  48.5   22009      44   5275  10.030    8.60    125
 11   550        0.0     0   17.5   5.8    2631      39   3310    .740   14.53     50
 12  1200        0.0     0   22.8   5.8    2654      63  44273    .350    5.50      5
 13  2300      310.0   136     .5 100.7   45659      66   4906  11.000    7.18     93
 14  2300      285.0   125    3.4  62.7   28459      37   2268    .850   13.63   2300
 15  2300      254.0   111    5.0  59.4   26957      43   2160   1.340   13.48   2250
 16  2300      232.0   102    6.0  56.3   25515      49   2274   1.630   13.18   2000
 17  2300      155.0    68   11.2  41.3   18711      63   1645    .930   13.63   1600
 18  2300       77.5    34   15.5  31.9   14465      33   1589   1.090   13.48    800
 19  2300       55.0    24   17.0  27.8   12624      35   1417    .930   13.48    590
 20  2300       24.8    11   18.5  23.9   10859      28   1065    .700   13.63    380
 21  2300        6.2     3   19.7  20.7    9385      24    696    .420   13.77    230
 22   550        0.0     0   17.5   5.8    2654      27   3545    .490   13.06     43
 23  2300        0.0     0   24.5   6.1    2758      62  25564    .070    2.37      3
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR           WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC        CO      NO2  FAC.       HP  ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------
  1    1.4    62.4      251      2.5  .070      0.0      R       R        R       R
  2    1.4     7.0       38      9.9  .060       .1    1.2     5.88     31.8     8.4
  3    1.9    11.4      132     22.1  .060       .3     .4     2.40     27.9     4.7
  4    3.2    29.1      169     45.5  .050       .5     .3     2.72     15.8     4.3
  5    7.1    35.9      154     84.3  .030       .4     .5     2.42     10.4     5.7
  6    3.1   131.4      661    229.8  .060      1.8     .1     4.43     22.3     7.7
  7    5.1   227.0     1245    448.5 0.000      0.0     .1     5.09     28.0    10.1
  8    6.4   258.5     1580    523.6  .040      1.9     .1     5.31     32.5    10.8
  9    8.6   261.0     1933    605.2 0.000      0.0     .2     4.78     35.4    11.1
 10   10.8   606.1    23276     47.7 0.000      0.0     .2    10.20    391.8      .8
 11    1.4    55.8      252      2.8  .070      0.0      R       R        R       R
 12    3.5  1143.1      183       .4  .120      0.0      R       R        R       R
 13   34.6  1199.8    54339     75.1  .025      3.4     .3     8.84    400.3      .6
 14   15.6   438.9     3323   1477.6  .055      6.9     .1     3.52     26.6    11.8
 15   16.7   387.3     4853   1339.3  .035      3.9     .2     3.48     43.6    12.0
 16   17.9   385.8     5587   1126.7  .060      6.1     .2     3.80     55.0    11.1
 17   17.2   209.1     2387    675.0  .060      4.1     .3     3.08     35.2     9.9
 18    6.9   156.0     2162    260.8 0.000      0.0     .2     4.60     63.7     7.7
 19    6.5   122.9     1630    169.9  .065      1.6     .3     5.10     67.7     7.1
 20    4.6    80.1     1064     94.9 0.000      0.0     .4     7.37     97.9     8.7
 21    3.4    45.8      558     50.3 0.000      0.0    1.3    16.86    205.7    18.5
 22    1.1    67.6      189      2.7  .080      0.0      R       R        R       R
 23    7.3  1411.1       78       .5  .060      0.0      R       R        R       R

CYCLE COMPOSITE      HC      11.914    GRAM/BHP HR
                     CO      80.724    GRAM/BHP HR
                     NO2      9.412    GRAM/BHP HR
                     ALDE      .226    GRAM/BHP HR
                     BSFC      .757      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
    4-17-72 RUN 2                     ENGINE 2-2             STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------------
               DYNA.        MAN.   FUEL RATE                DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR  GM/HR    ALDE.     HC       CO       CO2     NO
-------------------------------------------------------------------------------------
   1   550      0.0     0   17.5   5.8   2631       32   3503     .890     13.18     42
   2  1200      5.2     1   17.7  11.7   5289       21    168     .050     13.18     80
   3  1200     20.8     5   16.7  14.1   6378       24    292     .150     13.33    152
   4  1200     46.9    11   15.3  15.4   6981       33    597     .180     13.48    295
   5  1200     65.0    15   14.6  17.1   7775       56    688     .180     13.63    500
   6  1200    130.0    30   12.0  22.4  10170       24   2244     .520     13.91   1100
   7  1200    195.0    45    7.0  27.2  12329       27   2780     .930     13.63   1775
   8  1200    213.0    49    5.9  30.0  13608       27   2836    1.200     13.33   1875
   9  1200    239.0    55    3.4  32.1  14579       43   2780    1.380     13.18   2000
  10  1200    260.0    59    0.0  48.5  22009       43   5265   10.440      7.94    125
  11   550      0.0     0   17.5   5.8   2631       33   3723    1.160     12.71     50
  12  1200      0.0     0   22.8   5.8   2654       60  57007     .520      5.50      5
  13  2300    310.0   136     .5 100.7  45659       36   4910   11.000      7.28     93
  14  2300    285.0   125    3.4  62.7  28459       32   2223    1.340     13.77   2300
  15  2300    254.0   111    5.0  59.4  26957       36   2050    1.380     13.63   2250
  16  2300    232.0   102    6.2  56.3  25515       35   2109    1.660     13.48   2000
  17  2300    155.0    68   11.2  41.3  18711       54   1533     .890     13.77   1600
  18  2300     77.5    34   15.7  31.9  14465       57   1594    1.230     13.77    800
  19  2300     55.8    24   17.0  27.8  12624       27   1307    1.010     13.77    590
  20  2300     24.8    11   18.5  23.9  10859       24    933     .850     14.05    380
  21  2300      6.2     3   19.7  20.7   9385       28    712     .310     13.77    230
  22   550      0.0     0   17.5   5.8   2654       24   2930     .390     13.33     43
  23  2300      0.0     0   24.5   6.1   2758       43  21453     .070      2.26      3
-------------------------------------------------------------------------------------
            CALCULATED GRAM/HR          WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2   FAC.        HP  ALDE.       HC        CO     NO2
-------------------------------------------------------------------------------------
   1    1.2    63.9     328     2.5   .070       0.0      R        R         R       R
   2    1.8     6.7      40    10.6   .060        .1    1.5     5.66      33.9     8.9
   3    2.5    13.8     143    23.9   .060        .3     .5     2.90      30.1     5.0
   4    3.7    30.4     185    49.8   .050        .5     .3     2.84      17.3     4.7
   5    6.8    38.5     204    93.0   .030        .4     .5     2.59      13.7     6.3
   6    3.6   155.7     729   253.4   .060       1.8     .1     5.24      24.5     8.5
   7    4.9   231.0    1561   489.6  0.000       0.0     .1     5.18      35.0    11.0
   8    5.4   260.5    2227   571.8   .040       1.9     .1     5.35      45.8    11.7
   9    9.1   273.1    2739   652.4  0.000       0.0     .2     5.00      50.2    11.9
  10   10.8   612.9   24549    48.3  0.000       0.0     .2    10.32     413.2      .8
  11    1.3    68.8     433     3.1   .070       0.0      R        R         R       R
  12    2.9  1290.6     238      .4   .120       0.0      R        R         R       R
  13   18.7  1194.4   54049    74.7   .025       3.4     .1     8.80     398.1      .6
  14   13.0   412.5    5024  1417.4   .055       6.9     .1     3.31      40.3    11.4
  15   13.7   363.2    4939  1323.5   .035       3.9     .1     3.27      44.4    11.9
  16   12.5   350.6    5573  1103.6   .060       6.1     .1     3.45      54.9    10.9
  17   14.6   193.6    2271   671.0   .060       4.1     .2     2.85      33.5     9.9
  18   11.8   152.1    2371   253.4  0.000       0.0     .3     4.48      69.9     7.5
  19    5.0   110.7    1727   165.8   .065       1.6     .2     4.53      70.7     6.8
  20    3.8    67.6    1244    91.4  0.000       0.0     .4     6.22     114.5     8.4
  21    4.0    47.2     415    50.6  0.000       0.0    1.5    17.39     153.0    18.7
  22    1.0    55.5     149     2.7   .080       0.0      R        R         R       R
  23    5.7  1322.0      87      .6   .060       0.0      R        R         R       R

CYCLE COMPOSITE     HC      12.162   GRAM/BHP HR
                    CO      85.280   GRAM/BHP HR
                    NO2      9.347   GRAM/BHP HR
                    ALDE      .182   GRAM/BHP HR
                    BSFC      .756     LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-18-72 RUN 1                   ENGINE 2-2            STATIONARY DYNAMOMETER
---------------------------------------------------------------------------------
              DYNA.       MAN.   FUEL RATE               DRY CONCENTRATION
MODE SPEED    LOAD   HP   VAC. LB/HR  GM/HR   ALDE.    HC       CO      CO2     NO
---------------------------------------------------------------------------------
  1   550      0.0    0  17.5    5.8   2631      29  4535   1.120    13.33     36
  2  1200      5.2    1  17.7   11.7   5289      25   180    .050    13.33     83
  3  1200     20.8    5  16.8   14.1   6378      22   270    .100    13.63    131
  4  1200     46.8   11  15.3   15.4   6981      35   712    .210    13.91    255
  5  1200     65.0   15  14.7   17.1   7775      59   815    .210    14.05    360
  6  1200    130.0   30  11.8   22.4  10170      34  2090    .640    14.05    813
  7  1200    195.0   45   7.0   27.2  12329      32  3073   1.450    13.48   1100
  8  1200    213.0   49   5.8   30.0  13608      34  2965   1.410    13.77   1225
  9  1200    239.0   55   3.4   32.1  14579      43  2727   1.230    13.48   1500
 10  1200    260.0   59   0.0   48.5  22009      42  5328  10.350     8.14     89
 11   550      0.0    0  17.5    5.8   2631      38  4296   1.300    12.82     37
 12  1200      0.0    0  22.8    5.8   2654      59 58984    .440     5.27      4
 13  2300    310.0  136    .5  100.7  45659      29  5257  11.000     7.18     79
 14  2300    285.0  125   3.4   62.7  28459      24  2609   1.590    12.94   1700
 15  2300    254.0  111   4.9   59.4  26957      34  2440   1.660    12.94   1650
 16  2300    232.0  102   6.2   56.3  25515      29  2504   2.020    12.94   1450
 17  2300    155.0   68  11.0   41.3  18711      57  1868   1.120    13.18   1150
 18  2300     77.5   34  15.5   31.9  14465      45  1815   1.480    13.06    538
 19  2300     55.8   24  16.9   27.8  12624      27  1530   1.230    13.18    390
 20  2300     24.8   11  18.5   23.9  10859      29  1133   1.160    13.18    250
 21  2300      6.2    3  19.6   20.7   9385      34  6671    .640    13.48    175
 22   550      0.0    0  17.5    5.8   2654      22  3560   1.010    13.06     36
 23  2300      0.0    0  24.5    6.1   2758      43 23447    .150     1.95      2
---------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.      HC      CO     NO2
---------------------------------------------------------------------------------
  1    1.1    80.0     399     2.1  .070      0.0     R       R       R       R
  2    2.1     7.1      40    10.8  .060       .1   1.8    5.97    33.6     4.1
  3    2.2    12.5      94    20.2  .060       .3    .5    2.64    19.7     4.3
  4    3.8    35.0     209    41.6  .050       .5    .4    3.28    19.5     3.9
  5    6.9    44.2     230    64.8  .030       .4    .5    2.97    15.5     4.4
  6    5.0   142.7     882   184.1  .060      1.8    .2    4.80    29.7     6.2
  7    5.6   248.6    2370   295.5 0.000      0.0    .1    5.58    53.2     6.6
  8    6.4   260.7    2504   357.6  .040      1.9    .1    5.36    51.5     7.3
  9    9.1   265.3    2418   484.6 0.000      0.0    .2    4.86    44.3     8.9
 10   10.6   616.5   24189    34.1 0.000      0.0    .2   10.38   407.2      .6
 11    1.5    77.7     475     2.3  .070      0.0     R       R       R       R
 12    2.9  1342.5     225      .3  .120      0.0     R       R       R       R
 13   15.2  1283.1   54238    63.8  .025      3.4    .1    9.45   399.5      .5
 14   10.1   502.0    6180  1085.9  .055      6.9    .1    4.02    49.5     8.7
 15   13.2   443.2    6090   994.8  .035      3.9    .1    3.98    54.7     8.9
 16   10.5   420.1    6845   807.5  .060      6.1    .1    4.13    67.4     7.9
 17   15.9   241.3    2922   493.1  .060      4.1    .2    3.55    43.0     7.3
 18    9.5   178.4    2938   175.3 0.000      0.0    .3    5.26    86.6     5.2
 19    5.1   132.6    2154   112.2  .065      1.6    .2    5.43    88.1     4.6
 20    4.7    85.1    1761    62.4 0.000      0.0    .4    7.84   162.1     5.7
 21    4.6   423.4     821    36.9 0.000      0.0   1.7  155.93   302.2    13.6
 22     .9    65.5     375     2.2  .080      0.0     R       R       R       R
 23    5.7  1454.9     188      .4  .060      0.0     R       R       R       R

CYCLE COMPOSITE      HC      13.283    GRAM/BHP HR
                     CO      95.013    GRAM/BHP HR
                     NO2      6.885    GRAM/BHP HR
                     ALDE      .177    GRAM/BHP HR
                     BSFC      .256      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
    4-18-72 RUN 2                  ENGINE 2-2           STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------------------
              DYNA.           MAN.   FUEL  RATE                DRY CONCENTRATION
MODE SPEED    LOAD     HP   VAC.  LB/HR   GM/HR    ALDE.     HC        CO        CO2      NO
--------------------------------------------------------------------------------------------
  1    550      0.0     0   17.4    5.8    2631        0   4410      .970     13.18      35
  2   1200      5.2     1   17.0   11.7    5289        0    281      .070     13.18     100
  3   1200     20.8     5   16.4   14.1    6378        0    360      .130     13.33     132
  4   1200     46.8    11   15.3   15.4    6981        0    632      .180     13.77     230
  5   1200     65.0    15   14.7   17.1    7775        0    723      .180     13.91     290
  6   1200    130.0    30   11.4   22.4   10170        0   2380      .670     13.77     675
  7   1200    195.0    45    7.0   27.2   12329        0   3064     1.230     13.33    1050
  8   1200    213.0    49    6.3   30.0   13608        0   3236     1.450     13.18    1025
  9   1200    239.0    55    4.2   32.1   14579        0   3179     1.590     13.06    1100
 10   1200    260.0    59    0.0   48.5   22009        0   5797    10.560      7.94      83
 11    550      0.0     0   17.5    5.8    2631        0   4408     1.380     12.71      35
 12   1200      0.0     0   22.5    5.8    2654        0  58047      .490      5.50       5
 13   2300    310.0   136     .9  100.7   45659        0   5729    11.000      7.28      83
 14   2300    285.0   125    3.9   62.7   28459        0   2728     1.590     13.18    1700
 15   2300    254.0   111    5.3   59.4   26957        0   2613     1.660     13.06    1650
 16   2300    232.0   102    6.6   56.3   25515        0   2786     2.020     12.82    1350
 17   2300    155.0    68   11.0   41.3   18711        0   1984     1.120     13.33    1150
 18   2300     77.5    34   15.5   31.9   14465        0   1987     1.480     13.18     513
 19   2300     55.8    24   17.0   27.8   12624        0   1645     1.230     13.33     380
 20   2300     24.8    11   18.4   23.9   10859        0   1361     1.160     13.33     250
 21   2300      6.2     3   19.5   20.7    9385        0    725      .640     13.77     185
 22    550      0.0     0   17.6    5.8    2654        0   3613     1.010     12.94      39
 23   2300      0.0     0   24.4    6.1    2758        0  24037      .150      2.32       2
--------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.     WT.   BRAKE  SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2  FAC.      HP   ALDE.        HC        CO       NO2
--------------------------------------------------------------------------------------------
  1    0.0    79.5     353      2.1  .070     0.0       I         R         R         R
  2    0.0    11.2      56     13.2  .060      .1     0.0      9.41      47.4      11.1
  3    0.0    17.0     124     20.8  .060      .3     0.0      3.58      26.1       4.4
  4    0.0    31.5     181     38.0  .050      .5     0.0      2.95      16.9       3.6
  5    0.0    39.7     200     52.9  .030      .4     0.0      2.67      13.4       3.6
  6    0.0   164.9     938    155.3  .060     1.8     0.0      5.55      31.6       5.2
  7    0.0   254.1    2061    289.1 0.000     0.0     0.0      5.70      46.2       6.5
  8    0.0   294.5    2665    309.7  .040     1.9     0.0      6.05      54.8       6.4
  9    0.0   309.7    3128    355.7 0.000     0.0     0.0      5.67      57.3       6.5
 10    0.0   668.7   24606     31.6 0.000     0.0     0.0     11.26     414.2        .5
 11    0.0    79.8     505      2.1  .070     0.0       I         R         R         R
 12    0.0  1305.9     223       .4  .120     0.0       I         R         R         R
 13    0.0  1387.4   53814     66.3  .025     3.4     0.0     10.22     396.4        .5
 14    0.0   516.1    6076   1067.8  .055     6.9     0.0      4.13      48.7       8.6
 15    0.0   470.2    6034    985.7  .035     3.9     0.0      4.23      54.2       8.9
 16    0.0   470.2    6886    756.4  .060     6.1     0.0      4.63      67.8       7.4
 17    0.0   253.4    2890    487.7  .060     4.1     0.0      3.73      42.6       7.2
 18    0.0   193.5    2910    165.6 0.000     0.0     0.0      5.70      85.8       4.9
 19    0.0   141.1    2130    108.2  .065     1.6     0.0      5.77      87.2       4.4
 20    0.0   101.0    1740     61.6 0.000     0.0     0.0      9.30     160.2       5.7
 21    0.0    47.0     838     39.8 0.000     0.0     0.0     17.31     308.6      14.7
 22    0.0    67.0     328      2.4  .080     0.0       I         R         R         R
 23    0.0  1360.2     171       .4  .060     0.0       I         R         R         R

CYCLE COMPOSITE     HC      13.336    GRAM/BHP HR
                    CO      94.654    GRAM/BHP HR
                    NO2      6.598    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .756      LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-18-72 RUN 3                   ENGINE 2-2            STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------------
                DYNA.         MAN.   FUEL RATE                 DRY CONCENTRATION
MODE SPEED      LOAD    HP   VAC. LB/HR  GM/HR     ALDE.    HC        CO       CO2     NO
--------------------------------------------------------------------------------------
  1   550        0.0     0   17.6    5.8   2631        0   3642    1.010    13.91     39
  2  1200        5.2     1   17.2   11.7   5289        0    192     .070    13.63     98
  3  1200       20.8     5   16.4   14.1   6378        0    282     .130    13.77    138
  4  1200       46.8    11   15.3   15.4   6981        0    521     .180    14.05    250
  5  1200       65.0    15   14.5   17.1   7775        0    555     .150    14.18    355
  6  1200      130.0    30   11.4   22.4  10170        0   2094     .640    14.31    700
  7  1200      195.0    45    7.0   27.2  12329        0   2907    1.230    13.91   1075
  8  1200      213.0    49    6.3   30.0  13608        0   3023    1.450    13.77   1050
  9  1200      239.0    55    4.2   32.1  14579        0   2963    1.340    13.77   1250
 10  1200      260.0    59    0.0   48.5  22009        0   5757   10.480     8.43    100
 11   550        0.0     0   17.6    5.8   2631        0   3744    1.230    13.33     34
 12  1200        0.0     0   22.4    5.8   2654        0  58297     .520     5.96      5
 13  2300      310.0   136     .9  100.7  45659        0   5078   11.000     7.09     81
 14  2300      285.0   125    3.8   62.7  28459        0   2384    1.450    13.18   1850
 15  2300      254.0   111    5.6   59.4  26957        0   2271    1.730    12.94   1600
 16  2300      232.0   102    6.6   56.3  25515        0   2273    1.800    12.94   1550
 17  2300      155.0    68   11.0   41.3  18711        0   1812    1.120    13.18   1250
 18  2300       72.5    32   15.5   31.9  14465        0   1759    1.520    13.06    550
 19  2300       55.8    24   17.0   27.8  12624        0   1531    1.340    13.18    410
 20  2300       24.8    11   18.5   23.9  10859        0   1168    1.160    13.33    265
 21  2300        6.2     3   19.4   20.7   9385        0    611     .640    13.63    190
 22   550        0.0     0   17.5    5.8   2654        0   3273     .970    12.94     40
 23  2300        0.0     0   24.3    6.1   2758        0  21979     .150     2.26      3
--------------------------------------------------------------------------------------
           CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2   FAC.      HP  ALDE.      HC      CO     NO2
--------------------------------------------------------------------------------------
  1   0.0     62.7      351     2.2   .070     0.0      I       R       R       R
  2   0.0      7.4       55    12.5   .060      .1    0.0    6.22    45.9    10.5
  3   0.0     12.9      120    20.9   .060      .3    0.0    2.72    25.3     4.4
  4   0.0     25.4      178    40.6   .050      .5    0.0    2.38    16.6     3.8
  5   0.0     30.0      164    63.7   .030      .4    0.0    2.02    11.0     4.3
  6   0.0    140.5      867   155.9   .060     1.8    0.0    4.73    29.2     5.2
  7   0.0    232.3     1985   285.2  0.000     0.0    0.0    5.21    44.6     6.4
  8   0.0    265.0     2568   305.6   .040     1.9    0.0    5.45    52.8     6.3
  9   0.0    280.4     2561   392.7  0.000     0.0    0.0    5.14    46.9     7.2
 10   0.0    650.3    23911    37.5  0.000     0.0    0.0   10.95   402.5      .6
 11   0.0     66.0      438     2.0   .070     0.0      I       R       R       R
 12   0.0   1256.7      226      .3   .120     0.0      I       R       R       R
 13   0.0   1246.7    54552    66.2   .025     3.4    0.0    9.18   401.8      .5
 14   0.0    456.3     5606  1175.6   .055     6.9    0.0    3.66    44.9     9.4
 15   0.0    411.0     6324   961.2   .035     3.9    0.0    3.70    56.9     8.6
 16   0.0    387.4     6198   877.2   .050     6.1    0.0    3.81    61.0     8.6
 17   0.0    234.1     2923   536.2   .060     4.1    0.0    3.45    43.1     7.9
 18   0.0    172.4     3010   179.0  0.000     0.0    0.0    5.43    94.8     5.6
 19   0.0    131.7     2329   117.1   .065     1.6    0.0    5.39    95.3     4.8
 20   0.0     86.8     1742    65.4  0.000     0.0    0.0    8.00   160.4     6.0
 21   0.0     40.0      847    41.3  0.000     0.0    0.0   14.74   311.8    15.2
 22   0.0     61.0      365     2.5   .080     0.0      I       R       R       R
 23   0.0   1315.5      181      .5   .060     0.0      I       R       R       R

CYCLE COMPOSITE      HC      12.350     GRAM/BHP HR
                     CO      93.422     GRAM/BHP HR
                     NO2      7.118     GRAM/BHP HR
                     ALDE     0.000     GRAM/BHP HR
                     BSFC      .756       LB/BHP HR
```

APPENDIX E

EMISSION RESULTS FROM ENGINE 1-3

TABULAR FORM

ENGINE 1-3

NINE MODE FTP EMISSION RESULTS

CONCENTRATION BASIS

```
   4-24-72        ENGINE 1-3         RUN 1                                          K = .831     HUM =  36  GR/LB
   --------------------------------------------------------------------------------------------------------------------
   FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING          W E I G H T E D
   MODE           HC      CO     CO2     NO     FACTOR     HC     CO    NO     FACTOR         HC       CO       NO
   --------------------------------------------------------------------------------------------------------------------
CYCLE 1
   1 IDLE        423    .200  11.480     91     1.180     499   .826   107    .036         17.971    .030     3.866
   2 16'HG       102    .310  13.220   1059     1.033     105   .320  1094    .089          9.329    .029    97.373
   3 10'HG        87    .350  13.580   2573     1.042      91   .366  2694    .257         23.410    .094   692.347
   4 16'HG        55    .280  13.220   1229     1.038      57   .291  1276    .089          5.081    .026   113.536
   5 19'HG        26    .150  13.280    349     1.093      28   .163   378    .047          1.324    .008    17.772
   6 16'HG        49    .300  13.480   1211     1.060      52   .318  1283    .089          4.621    .028   114.215
   7  3'HG        33    .250  13.180   1473     1.082      36   .272  1601    .283         10.151    .077   453.086
   8 16'HG        39    .310  13.630   1229     1.049      41   .325  1289    .089          3.640    .029   114.704
   9 C.T.       1096    .170   5.680     94     2.087    2287   .355   196    .021         48.028    .007     4.119
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------   123.605    .328  1611.017
CYCLE 2
   1 IDLE        423    .200  11.480     91     1.180     499   .826   107    .036         17.971    .030     3.866
   2 16'HG       349    .500  13.580   1134     1.021     356   .510  1157    .089         31.702    .045   103.008
   3 10'HG        71    .310  13.480   2697     1.057      75   .328  2852    .257         19.296    .084   732.979
   4 16'HG        35    .180  13.180   1241     1.090      38   .196  1352    .089          3.394    .017   120.344
   5 19'HG        13    .340  13.480    363     1.061      14   .361   385    .047           .648    .017    18.105
   6 16'HG        39    .220  13.060   1659     1.097      43   .241  1821    .089          3.809    .021   162.044
   7  3'HG        21    .270  13.180   1947     1.087      23   .294  2117    .283          6.461    .083   599.018
   8 16'HG        31    .350  13.480   1325     1.059      33   .371  1404    .089          2.923    .033   124.916
   9 C.T.       1143    .160   5.520     86     2.122    2425   .339   182    .021         50.925    .007     3.832
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------   137.129    .339  1868.111
CYCLE 3
   1 IDLE        278    .520  11.840     90     1.169     325   .608   105    .036         11.703    .022     3.789
   2 16'HG        66    .390  13.480   1150     1.055      70   .411  1213    .089          6.196    .037   107.962
   3 10'HG        75    .400  13.490   2739     1.054      79   .421  2886    .257         20.310    .108   741.725
   4 16'HG        39    .380  13.480   1283     1.057      41   .402  1357    .089          3.670    .036   120.748
   5 19'HG        17    .440  13.180    363     1.081      19   .475   392    .047           .863    .022    18.436
   6 16'HG        39    .360  13.480   1313     1.058      41   .381  1389    .089          3.673    .034   123.662
   7  3'HG        21    .270  13.180   1968     1.087      23   .294  2140    .283          6.461    .083   605.479
   8 16'HG        35    .410  13.530   1313     1.053      37   .432  1382    .089          3.279    .038   123.027
   9 C.T.       1105    .240   5.860     74.    2.021    2234   .485   150    .021         46.906    .010     3.141
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------   103.062    .391  1847.969
CYCLE 4
   1 IDLE        278    .520  11.840     90     1.169     325   .608   105    .036         11.703    .022     3.789
   2 16'HG        92    .390  13.840   1217     1.026      94   .400  1248    .089          8.400    .036   111.115
   3 10'HG        75    .390  13.330   2791     1.066      80   .416  2974    .257         20.541    .107   764.417
   4 16'HG        39    .310  13.480   1313     1.060      41   .329  1392    .089          3.680    .029   123.888
   5 19'HG        22    .180  13.060    363     1.101      24   .198   400    .047          1.138    .009    18.779
   6 16'HG        53    .320  13.060   1301     1.092      58   .349  1421    .089          5.151    .031   126.453
   7  3'HG        61    .210  13.100   1988     1.093      67   .229  2172    .283         18.862    .065   614.711
   8 15'HG        31    .360  13.480   1369     1.059      33   .381  1450    .089          2.921    .034   129.017
   9 C.T.       1049    .210   5.800     75     2.063    2146   .433   155    .021         45.058    .009     3.249
   SUM------------(CYCLE COMPOSITE)---------------------------------------------------   117.455    .342  1895.417

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)--------------------------------   130.367    .333  1739.564

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)--------------------------------   110.258    .366  1871.693

   FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  130.367) + 0.65*(  110.258) =   117.296  PPM
                                               CO    0.35*(     .333) + 0.65*(     .366) =      .355  PERCENT
                                               NO    0.35*( 1739.564) + 0.65*( 1871.693) =  1825.448  PPM
                                                                        CORRECTED NO =  1516.638  PPM

   DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
   4-25-72         ENGINE 1-4           RUN 2                               K = .902      HUM =  51  GR/LB
   ---------------------------------------------------------------------------------------------------------------
   FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D    WEIGHTING        W E I G H T E D
   MODE            HC      CO     CO2     NO    FACTOR     HC      CO    NO      FACTOR         HC      CO       NO
   ---------------------------------------------------------------------------------------------------------------
CYCLE 1
   1 IDLE         449    .490  11.600     77     1.176     528    .576     91     .036        19.009    .021     3.260
   2 16'HG        114    .300  13.910   1054     1.022     117    .307   1078     .089        10.373    .027    95.902
   3 10'HG        107    .310  13.580   1867     1.047     112    .325   1955     .257        28.788    .083   502.317
   4 16'HG         71    .220  13.880   1241     1.029      73    .228   1277     .089         6.502    .025   113.649
   5 19'HG         37    .130  13.180    321     1.091      40    .142    350     .047         1.898    .007    16.467
   6 16'HG         61    .250  13.500   1152     1.059      65    .265   1220     .089         5.750    .024   108.587
   7  3'HG         43    .210  13.400   1738     1.070      46    .225   1860     .283        13.021    .054   526.282
   8 16'HG         50    .270  13.290   1247     1.037      52    .280   1293     .089         4.616    .025   115.119
   9 C.T.        1245    .190   6.030     87     1.941    2417    .369    169     .021        50.753    .008     3.547
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------   140.709    .283  1485.131
CYCLE 2
   1 IDLE         449    .490  11.600     77     1.176     528    .576     91     .036        19.009    .021     3.260
   2 16'HG         71    .270  13.480   1117     1.059      75    .286   1183     .089         6.692    .025   105.282
   3 10'HG         84    .300  13.480   2647     1.057      89    .317   2797     .257        22.814    .081   718.916
   4 16'HG         53    .260  13.630   1277     1.049      56    .273   1340     .089         4.950    .024   119.269
   5 19'HG         26    .130  13.180    321     1.092      28    .142    351     .047         1.335    .007    16.482
   6 16'HG         49    .280  13.630   1187     1.049      51    .294   1245     .089         4.575    .026   110.818
   7  3'HG         35    .210  13.180   1876     1.088      38    .229   2042     .283        10.780    .065   577.819
   8 16'HG         49    .350  13.720   1313     1.040      51    .364   1365     .089         4.534    .032   121.482
   9 C.T.        1239    .190   6.290     93     1.877    2326    .357    175     .021        48.850    .007     3.667
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------   123.539    .289  1776.994
CYCLE 3
   1 IDLE         416    .530  11.920     77     1.148     477    .608     88     .036        17.188    .022     3.181
   2 16'HG         82    .330  13.450   1438     1.058      87    .349   1522     .089         7.722    .031   135.420
   3 10'HG         75    .310  13.250   2656     1.075      81    .333   2856     .257        20.724    .086   733.915
   4 16'HG         49    .260  13.480   1229     1.061      52    .276   1304     .089         4.628    .025   116.082
   5 19'HG         26    .120  13.120    334     1.098      29    .132    367     .047         1.342    .006    17.233
   6 16'HG         50    .250  13.480   1344     1.062      53    .265   1427     .089         4.724    .024   126.981
   7  3'HG         33    .200  13.180   1841     1.089      36    .218   2005     .283        10.170    .062   567.344
   8 16'HG         44    .310  13.630   1274     1.048      46    .325   1335     .089         4.105    .029   118.857
   9 C.T.        1159    .180   5.960    108     1.986    2302    .357    214     .021        48.333    .008     4.504
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------   118.935    .291  1823.519
CYCLE 4
   1 IDLE         416    .530  11.920     77     1.148     477    .608     88     .036        17.188    .022     3.181
   2 16'HG         78    .280  13.480   1170     1.058      83    .296   1238     .089         7.345    .026   110.176
   3 10'HG         79    .350  13.480   2655     1.055      83    .369   2802     .257        21.426    .095   720.060
   4 16'HG         53    .280  13.550   1298     1.055      56    .295   1369     .089         4.975    .026   121.848
   5 19'HG         26    .120  13.180    312     1.093      28    .131    341     .047         1.335    .006    16.026
   6 16'HG         46    .270  13.480   1232     1.061      49    .287   1307     .089         4.344    .025   116.351
   7  3'HG         33    .230  13.180   1925     1.088      36    .250   2094     .283        10.158    .071   592.563
   8 16'HG         42    .310  13.630   1259     1.048      44    .325   1320     .089         3.919    .029   117.476
   9 C.T.        1185    .200   6.020    109     1.960    2322    .392    214     .021        48.762    .008     4.485
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------   119.453    .309  1802.166

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------   132.124    .286  1631.062

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------   119.194    .300  1812.842

   FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  132.124) + 0.65*(  119.194) =   123.720  PPM
                                               CO    0.35*(     .286) + 0.65*(     .300) =      .295  PERCENT
                                               NO    0.35*( 1631.062) + 0.65*( 1812.842) =  1749.219  PPM
                                                                            CORRECTED NO =  1578.167  PPM

   DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
   4-25-72        ENGINE 1-4          RUN 3                                        K = .810       HUM =  32  GR/LB
 ---------------------------------------------------------------------------------------------------------------------
 FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D   WEIGHTING         W E I G H T E D
 MODE            HC      CO     CO2     NO     FACTOR      HC      CO    NO      FACTOR        HC       CO        NO
 ---------------------------------------------------------------------------------------------------------------------
CYCLE 1
 1 IDLE          374    .530  11.600     80     1.182      442    .626    95      .036       15.912    .023      3.404
 2 16'HG         104    .230  13.550   1100     1.052      109    .242  1158      .089        9.742    .022    103.035
 3 10'HG          93    .270  13.480   2606     1.057       98    .285  2755      .257       25.268    .073    708.053
 4 16'HG          57    .210  13.530   1198     1.059       60    .222  1258      .089        5.371    .020    111.934
 5 19'HG          37    .120  13.120    307     1.097       41    .132   337      .047        1.907    .006     15.826
 6 16'HG          46    .210  13.480   1223     1.063       49    .223  1301      .089        4.354    .020    115.755
 7  3'HG          41    .190  13.150   1738     1.091       45    .207  1896      .283       12.660    .059    536.664
 8 16'HG          40    .250  13.440   1260     1.028       41    .257  1295      .089        3.659    .023    115.254
 9 C.T.         1272    .180   5.460     97     1.980     2518    .356   192      .021       52.886    .007      4.033
 SUM------------(CYCLE COMPOSITE)---------------------------------------------------------  131.759    .252   1713.959
CYCLE 2
 1 IDLE          374    .530  11.600     80     1.182      442    .626    95      .036       15.912    .023      3.404
 2 16'HG          66    .260  13.550   1117     1.054       70    .274  1178      .089        6.194    .024    104.826
 3 10'HG          73    .330  13.580   2723     1.049       77    .346  2856      .257       19.679    .089    734.041
 4 16'HG          41    .180  13.720   1277     1.047       43    .188  1337      .089        3.819    .017    118.950
 5 19'HG          17    .160  13.180    321     1.092       19    .175   351      .047         .873    .008     16.475
 6 16'HG          40    .180  13.630   1260     1.054       42    .190  1327      .089        3.751    .017    118.143
 7  3'HG          22    .240  13.180   1821     1.088       24    .261  1982      .283        6.776    .074    560.838
 8 16'HG          31    .350  13.720   1338     1.041       32    .364  1393      .089        2.872    .032    123.968
 9 C.T.         1156    .250   5.860     97     2.005     2317    .501   194      .021       48.663    .011      4.083
 SUM------------(CYCLE COMPOSITE)---------------------------------------------------------  108.538    .295   1784.728
CYCLE 3
 1 IDLE          438    .480  12.220     90     1.121      491    .538   101      .036       17.678    .019      3.633
 2 16'HG          68    .300  13.480   1241     1.058       72    .317  1313      .089        6.404    .028    116.869
 3 10'HG          71    .300  13.480   2843     1.058       75    .317  3008      .257       19.303    .082    772.940
 4 16'HG          40    .230  13.550   1376     1.058       42    .243  1455      .089        3.766    .022    129.538
 5 19'HG          17    .140  13.180    363     1.093       19    .153   397      .047         .873    .007     18.645
 6 16'HG          37    .250  13.200   1284     1.046       39    .261  1343      .089        3.444    .023    119.510
 7  3'HG          22    .160  13.330   1925     1.079       24    .173  2078      .283        6.720    .049    588.014
 8 16'HG          31    .280  13.770   1351     1.040       32    .291  1405      .089        2.869    .026    125.038
 9 C.T.         1125    .170   5.890    102     2.017     2269    .343   206      .021       47.644    .007      4.320
 SUM------------(CYCLE COMPOSITE)---------------------------------------------------------  108.702    .263   1878.506
CYCLE 4
 1 IDLE          438    .480  12.220     90     1.121      491    .538   101      .036       17.678    .019      3.633
 2 16'HG          74    .320  13.770   1206     1.035       77    .331  1248      .089        6.816    .029    111.089
 3 10'HG          74    .280  13.660   2791     1.045       77    .293  2916      .257       19.868    .075    749.332
 4 16'HG          49    .230  13.770   1289     1.040       51    .239  1341      .089        4.537    .021    119.347
 5 19'HG          18    .120  13.330    345     1.081       19    .130   373      .047         .915    .006     17.534
 6 16'HG          40    .280  13.660   1381     1.047       42    .293  1447      .089        3.729    .026    128.741
 7  3'HG          19    .160  13.400   2062     1.074       20    .172  2215      .283        5.775    .049    626.747
 8 16'HG          31    .270  13.770   1351     1.040       32    .281  1405      .089        2.870    .025    125.083
 9 C.T.         1108    .170   5.530    112     2.129     2359    .362   238      .021       49.531    .008      5.007
 SUM------------(CYCLE COMPOSITE)---------------------------------------------------------  111.719    .259   1886.511

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------------  120.148    .273   1749.344

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------------  110.210    .261   1882.509

 FOUR CYCLE COMPOSITE - REPORTED VALUES -     HC     0.35*(  120.148) + 0.65*(  110.210) =    113.689  PPM
                                              CO     0.35*(     .273) + 0.65*(     .261) =       .265  PERCENT
                                              NO     0.35*( 1749.344) + 0.65*( 1882.509) =   1835.901  PPM
                                                                          CORRECTED NO =   1487.920  PPM

 DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

167

ENGINE 1-3

NINE MODE FTP EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
   4-24-72        ENGINE 1-4          RUN 1                          K =  .84     HUM =  36  GR/LB
 ------------------------------------------------------------------------------------------------------------
   MASS        CONCENTRATION AS MEASURED     TOTAL     FUEL      ADJUSTED (MASS)      WT.       WEIGHTED (MASS)
   MODE         HC      CO     CO2     NO   CARBON    CONS.      HC      CO    NO2   FACT.     HC      CO  NO2(K)  HP
 ------------------------------------------------------------------------------------------------------------

CYCLE 1
   1 IDLE       423   .700  11.48     91   12.637    2115      76     237      5   .232     17.7     55     1.2    0
   2 16 HG      102   .310  13.77   1059   14.190    9263      72     409    230   .077      5.5     31    17.7   22
   3 10 HG       87   .350  13.58   2573   14.024   13518      91     681    823   .147     13.3    100   121.0   53
   4 16 HG       55   .280  13.77   1229   14.109    9263      39     371    268   .077      3.0     29    20.6   22
   5 19 HG       26   .150  13.28    349   13.458    6754      14     152     58   .057       .8      9     3.3    4
   6 16 HG       49   .300  13.48   1211   13.833    9263      35     406    269   .077      2.7     31    20.7   22
   7  3 HG       33   .250  13.18   1473   13.466   19613      52     736    712   .113      5.9     83    80.5   69
   8 16 HG       39   .310  13.63   1229   13.982    9263      28     415    270   .077      2.1     32    20.8   22
   9 C.T.      1096   .170   5.68     94    7.034    2261     380     110     10   .143     54.4     16     1.4    0
   SUM------------(CYCLE COMPOSITE)----------------------------------------------       4.7     17    12.7

CYCLE 2
   1 IDLE       423   .700  11.48     91   12.637    2115      76     237      5   .232     17.7     55     1.2    0
   2 16 HG      349   .500  13.58   1134   14.457    9263     242     647    241   .077     18.6     50    18.6   22
   3 10 HG       71   .310  13.48   2697   13.867   13518      75     610    873   .147     11.0     90   128.3   53
   4 16 HG       35   .180  13.18   1241   13.398    9263      26     251    285   .077      2.0     19    21.9   22
   5 19 HG       13   .340  13.48    363   13.834    6754       7     335     59   .057       .4     19     3.4    4
   6 16 HG       39   .220  13.06   1659   13.322    9263      29     309    383   .077      2.3     24    29.5   22
   7  3 HG       21   .270  13.18   1947   13.473   19613      33     794    941   .113      3.7     90   106.3   69
   8 16 HG       31   .350  13.48   1325   13.863    9263      22     472    294   .077      1.7     36    22.6   22
   9 C.T.      1143   .160   5.52     86    6.914    2261     404     106      9   .143     57.7     15     1.3    0
   SUM------------(CYCLE COMPOSITE)----------------------------------------------       5.1     18    14.8

CYCLE 3
   1 IDLE       228   .520  11.84     90   12.660    2115      50     175      5   .232     11.6     41     1.2    0
   2 16 HG       66   .390  13.48   1150   13.941    9263      47     523    254   .077      3.6     40    19.5   22
   3 10 HG       75   .400  13.48   2739   13.961   13518      78     782    880   .147     11.5    115   129.4   53
   4 16 HG       39   .380  13.48   1283   13.902    9263      28     511    284   .077      2.2     39    21.9   22
   5 19 HG       17   .440  13.18    363   13.638    6754       9     440     60   .057       .5     25     3.4    4
   6 16 HG       39   .360  13.48   1313   13.882    9263      28     485    291   .077      2.2     37    22.4   22
   7  3 HG       21   .270  13.18   1968   13.473   19613      33     794    951   .113      3.7     90   107.5   69
   8 16 HG       35   .410  13.53   1313   13.978    9263      25     549    289   .077      1.9     42    22.2   22
   9 C.T.      1105   .240   5.86     74    7.293    2261     370     150      8   .143     52.9     21     1.1    0
   SUM------------(CYCLE COMPOSITE)----------------------------------------------       4.0     20    14.6

CYCLE 4
   1 IDLE       228   .520  11.84     90   12.660    2115      50     175      5   .232     11.6     41     1.2    0
   2 16 HG       92   .390  13.84   1217   14.329    9263      64     509    261   .077      4.9     39    20.1   22
   3 10 HG       75   .390  13.33   2791   13.801   13518      79     772    908   .147     11.7    113   133.4   53
   4 16 HG       39   .310  13.48   1313   13.832    9263      28     419    292   .077      2.2     32    22.5   22
   5 19 HG       22   .180  13.06    363   13.264    6754      12     185     61   .057       .7     11     3.5    4
   6 16 HG       53   .320  13.06   1301   13.437    9263      39     446    298   .077      3.0     34    22.9   22
   7  3 HG       61   .210  13.10   1988   13.376   19613      97     622    968   .113     10.9     70   109.4   69
   8 16 HG       31   .360  13.48   1369   13.873    9263      22     486    303   .077      1.7     37    23.4   22
   9 C.T.      1040   .210   5.80     75    7.133    2261     356     134      8   .143     50.9     14     1.1    0
   SUM------------(CYCLE COMPOSITE)----------------------------------------------       4.3     18    15.0

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------       4.9     17    13.8

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------       4.2     19    14.8

   FOUR CYCLE COMPOSITE = REPORTED VALUES - HC  0.35(     4.9) + 0.65(     4.2) =    4.422  (MASS)
                                            CO  0.35(      17) + 0.65(      19) =     18.3  (MASS)
                                            NO2 0.35(    13.8) + 0.65(    14.8) =   14.417  (MASS)
                                                           CORRECTED NO2 =   12.120  (MASS)
```

```
    4-25-77        ENGINE 1-3          RUN 2                                    K =  .91     HUM =  51  GR/LB
    ---------------------------------------------------------------------------------------------------------------------
    MASS         CONCENTRATION AS MEASURED      TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
    MODE          HC      CO     CO2     NO    CARBON   CONS.      HC      CO     NO2   FACT.      HC        CO   NO2(K)  HP
    ---------------------------------------------------------------------------------------------------------------------

CYCLE 1
    1 IDLE        449    .490  11.60     77    12.575    2115      82     166       4   .232     18.9       39     1.0    0
    2 16 HG       114    .300  13.91   1054    14.333    9263      80     392     226   .077      6.1       30    17.4   22
    3 10 HG       107    .310  13.58   1867    14.006   13518     112     604     598   .147     16.4       84    87.9   53
    4 16 HG        71    .220  13.88   1241    14.227    9263      50     355     268   .077      3.8       27    20.7   22
    5 19 HG        37    .130  13.18    321    13.350    6754      20     133      54   .057      1.2        8     3.1    4
    6 16 HG        61    .250  13.50   1152    13.816    9263      44     339     256   .077      3.4       26    19.7   22
    7  3 HG        43    .210  13.40   1238    13.656   19613      67     609     829   .113      7.5       69    93.6   69
    8 16 HG        50    .270  13.29   1247    14.114    9263      35     358     272   .077      2.7       28    20.9   22
    9 C.T.       1245    .190   6.03     87     7.565    2261     402     114       9   .143     57.5       16     1.2    0
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     5.2       15    11.8

CYCLE 2
    1 IDLE        449    .490  11.60     77    12.575    2115      82     166       4   .232     18.9       34     1.0    0
    2 16 HG        71    .220  13.48   1117    13.827    9263      51     365     248   .077      4.0       28    19.1   22
    3 10 HG        84    .300  13.48   2647    13.871   13518      88     591     856   .147     13.0       87   125.9   53
    4 16 HG        53    .260  13.64   1277    13.947    9263      38     349     282   .077      2.9       27    21.7   22
    5 19 HG        26    .130  13.18    321    13.338    6754      14     133      54   .057       .8        8     3.1    4
    6 16 HG        49    .280  13.63   1187    13.963    9263      35     375     261   .077      2.7       24    20.1   22
    7  3 HG        35    .210  13.18   1876    13.428   19613      55     620     910   .113      6.2       70   102.8   69
    8 16 HG        49    .350  13.72   1313    14.123    9263      35     464     286   .077      2.7       36    22.0   22
    9 C.T.       1239    .190   6.29     93     7.818    2261     387     111       9   .143     55.3       16     1.3    0
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     4.7       15    14.1

CYCLE 3
    1 IDLE        416    .530  11.92     77    12.899    2115      74     176       4   .232     17.1       41     1.0    0
    2 16 HG        82    .330  13.45   1438    13.869    9263      59     445     319   .077      4.6       34    24.6   22
    3 10 HG        75    .310  13.25   2656    13.641   13518      80     621     874   .147     11.8       91   128.5   53
    4 16 HG        49    .260  13.48   1229    13.793    9263      36     353     274   .077      2.7       27    21.1   22
    5 19 HG        26    .120  13.12    334    13.268    6754      14     123      56   .057       .8        7     3.2    4
    6 16 HG        50    .250  13.48   1344    13.784    9263      36     339     300   .077      2.8       26    23.1   22
    7  3 HG        33    .200  13.18   1841    13.416   19613      52     591     894   .113      5.9       67   101.0   69
    8 16 HG        44    .310  13.63   1274    13.988    9263      31     415     280   .077      2.4       32    21.6   22
    9 C.T.       1159    .180   5.96    108     7.392    2261     383     111      11   .143     54.7       16     1.6    0
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     4.6       15    14.4

CYCLE 4
    1 IDLE        416    .530  11.92     77    12.899    2115      74     176       4   .232     17.1       41     1.0    0
    2 16 HG        78    .280  13.48   1170    13.844    9263      56     378     260   .077      4.3       29    20.0   22
    3 10 HG        79    .350  13.48   2655    13.915   13518      83     687     856   .147     12.2      101   125.9   53
    4 16 HG        53    .280  13.55   1238    13.887    9263      38     377     287   .077      2.9       29    22.1   22
    5 19 HG        26    .120  13.18    312    13.328    6754      14     123      52   .057       .8        7     3.0    4
    6 16 HG        46    .270  13.48   1232    13.800    9263      33     366     275   .077      2.6       28    21.1   22
    7  3 HG        33    .230  13.18   1925    13.446   19613      52     678     932   .113      5.9       77   105.3   69
    8 16 HG        42    .310  13.63   1259    13.985    9263      30     415     277   .077      2.3       32    21.3   22
    9 C.T.       1185    .200   6.02    109     7.500    2261     386     122      11   .143     55.2       17     1.6    0
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     4.6       16    14.3

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------     5.0       15    12.9

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------     4.6       16    14.3

    FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     5.0) + 0.65(     4.6) =    4.712  (MASS)
                                             CO  0.35(      15) + 0.65(      16) =     15.3  (MASS)
                                             NO2 0.35(    12.9) + 0.65(    14.3) =   13.847  (MASS)
                                                              CORRECTED NO2 =   12.598  (MASS)
```

```
   4-25-72          ENGINE 1-4           RUN 3                                 K =  .82      HUM =  32  GR/LB
-----------------------------------------------------------------------------------------------------------------------
MASS        CONCENTRATION AS MEASURED     TOTAL     FUEL      ADJUSTED (MASS)         WT.        WEIGHTED (MASS)
MODE          HC      CO     CO2     NO   CARBON    CONS.     HC      CO     NO2     FACT.     HC       CO   NO2(K)  HP
-----------------------------------------------------------------------------------------------------------------------
CYCLE 1
   1 IDLE     374    .530  11.60     80   12.534    2115      68     181       4    .232     15.8      42     1.0    0
   2 16 HG    104    .230  13.55   1100   13.892    9263      75     310     244    .077      5.8      24    18.7   22
   3 10 HG     93    .220  13.48   2606   13.850   13518      98     532     844    .147     14.4      78   124.1   53
   4 16 HG     57    .210  13.53   1188   13.802    9263      41     285     265    .077      3.2      22    20.4   22
   5 19 HG     37    .120  13.12    307   13.280    6754      20     123      52    .057      1.2       7     3.0    4
   6 16 HG     46    .210  13.48   1223   13.740    9263      33     286     274    .077      2.6      22    21.1   22
   7  3 HG     41    .190  13.15   1738   13.384   19613      65     562     946    .113      7.3      64    95.5   69
   8 16 HG     60    .250  13.94   1260   14.233    9263      28     329     272    .077      2.2      25    21.0   22
   9 C.T.    1272    .180   5.86     97    7.414    2261     419     111      10    .143     59.9      16     1.4    0
   SUM------ ------(CYCLE COMPOSITE)-----------------------------------------------            5.0      13    13.6
CYCLE 2
   1 IDLE     374    .530  11.60     80   12.534    2115      68     181       4    .232     15.8      42     1.0    0
   2 16 HG     66    .260  13.55   1117   13.881    9263      48     350     247    .077      3.7      27    19.1   22
   3 10 HG     73    .230  13.58   2723   13.989   13518      76     614     874    .147     11.2      95   128.4   53
   4 16 HG     41    .180  13.72   1277   13.944    9263      29     242     282    .077      2.3      19    21.7   22
   5 19 HG     17    .160  13.18    321   13.358    6754       9     163      54    .057       .5       9     3.1    4
   6 16 HG     40    .180  13.63   1260   13.853    9263      24     243     280    .077      2.2      19    21.5   22
   7  3 HG     22    .240  13.18   1821   13.444   19614      35     707     882    .113      3.9      80    99.7   69
   8 16 HG     31    .250  13.72   1338   14.103    9263      22     464     292    .077      1.7      36    22.5   22
   9 C.T.    1156    .250   5.86     97    7.358    2261     384     155      10    .143     54.9      22     1.4    0
   SUM------------(CYCLE COMPOSITE)------------------------------------------------            4.3      15    14.1
CYCLE 3
   1 IDLE     438    .480  12.22     90   13.173    2115      76     156       5    .232     17.6      36     1.1    0
   2 16 HG     68    .300  13.48   1241   13.853    9263      49     405     275    .077      3.8      31    21.2   22
   3 10 HG     71    .300  13.48   2843   13.857   13518      75     591     921    .147     11.0      87   135.4   53
   4 16 HG     40    .230  13.55   1376   13.823    9263      29     311     306    .077      2.2      24    23.6   22
   5 19 HG     17    .140  13.18    363   13.338    6754       9     143      61    .057       .5       8     3.5    4
   6 16 HG     37    .250  13.70   1284   13.990    9263      26     334     282    .077      2.0      26    21.7   22
   7  3 HG     22    .160  13.33   1925   13.514   19613      34     469     928    .113      3.9      53   104.8   69
   8 16 HG     31    .280  13.77   1351   14.083    9263      22     372     295    .077      1.7      29    22.7   22
   9 C.T.    1125    .170   5.89    102    7.275    2261     378     107      11    .143     54.0      15     1.5    0
   SUM------------(CYCLE COMPOSITE)------------------------------------------------            4.3      14    14.9
CYCLE 4
   1 IDLE     438    .480  12.22     90   13.173    2115      76     156       5    .232     17.6      36     1.1    0
   2 16 HG     74    .320  13.77   1206   14.170    9263      52     423     262    .077      4.0      33    20.2   22
   3 10 HG     74    .280  13.66   2791   14.020   13518      77     545     893    .147     11.3      80   131.3   53
   4 16 HG     49    .230  13.77   1289   14.053    9263      35     306     282    .077      2.7      24    21.7   22
   5 19 HG     18    .120  13.33    345   13.469    6754      10     122      57    .057       .6       7     3.3    4
   6 16 HG     40    .280  13.66   1381   13.983    9263      29     375     304    .077      2.2      29    23.4   22
   7  3 HG     19    .160  13.40   2062   13.581   19613      30     467     989    .113      3.3      53   111.7   69
   8 16 HG     31    .220  13.77   1351   14.073    9263      22     359     295    .077      1.7      26    22.7   22
   9 C.T.    1108    .120   5.53    112    6.897    2261     392     113      12    .143     56.1      16     1.7    0
   SUM------------(CYCLE COMPOSITE)------------------------------------------------            4.4      14    15.0

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------            4.6      14    13.9

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------            4.4      14    14.9

   FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     4.6) + 0.65(     4.4) =     4.449  (MASS)
                                            CO  0.35(      14) + 0.65(      14) =      13.9  (MASS)
                                            NO2 0.35(    13.9) + 0.65(    14.9) =    14.545  (MASS)
                                                                CORRECTED NO2 =    11.935  (MASS)
```

ENGINE 1-3

EXPERIMENTAL 23 MODE EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
   4-27-72 RUN 2                       ENGINE 1-3            STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------
                 DYNA.        MAN.   FUEL  RATE                DRY CONCENTRATION
MODE SPEED       LOAD    HP   VAC. LB/HR   GM/HR     ALDE.      HC       CO      CO2     NO
-----------------------------------------------------------------------------------
  1    600        0.0     0   18.5   4.9    2228        35    7793     .520    11.72     24
  2   1200        5.0     1   19.2   9.2    4155        32    1743     .280    13.18    130
  3   1200       19.0     4   18.5   9.5    4314        40    1348     .150    13.18    215
  4   1200       42.0    10   17.1  10.8    4892        63    1459     .130    13.06    380
  5   1200       59.0    13   16.2  12.0    5424        62    1795     .100    13.06    505
  6   1200      117.5    27   11.6  16.1    7283        75    2361     .100    13.33   1900
  7   1200      176.0    40    3.4  23.9   10841       188    1465     .280    13.48   1600
  8   1200      192.5    44    1.1  24.8   11261        49    1636     .390    13.48   1700
  9   1200      216.0    49     .6  27.7   12560        38    2736    1.940    13.18   1275
 10   1200      235.0    54    0.0  35.1   15931        31    4215    5.720    11.01    525
 11    600        0.0     0   18.5   4.9    2228        41    4152     .610    12.59     31
 12   1200        0.0     0   22.4   5.2    2375        51   58470     .210     3.56      3
 13   2300      255.0   112     .5  66.0   29938        59    3358    5.240    11.84    600
 14   2300      234.5   103    1.4  55.6   25220        26    2405    1.800    13.91   1800
 15   2300      209.0    92    1.6  49.4   22388        28     396     .150    14.18   2500
 16   2300      191.0    84    3.4  47.4   21503        20     278     .210    14.18   2250
 17   2300      127.5    56   11.2  33.6   15249        31    1761     .520    14.18   2800
 18   2300       64.0    28   15.5  24.1   10929        25    1248     .490    14.05   1438
 19   2300       46.0    20   17.0  21.1    9566        40     855     .350    14.79    913
 20   2300       20.0     9   18.4  18.0    8165        42     340     .210    14.05    440
 21   2300        5.0     2   19.1  15.2    6902        21     226     .210    14.05    300
 22    600        0.0     0   18.5   4.7    2127        29    4807     .280    12.47     28
 23   2300        0.0     0   24.4   4.7    2134        67   20518     .100     2.70      2
-----------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.      HC       CO      NO2
-----------------------------------------------------------------------------------
  1    1.3   133.3     180     1.4   .020      0.0      R        R        R        R
  2    2.1    53.1     172    13.2   .060       .1    1.9    46.49    150.9     11.5
  3    2.8    43.2      97    22.9   .060       .3     .6     9.95     22.4      5.3
  4    5.0    53.5      96    46.3   .050       .5     .5     5.58     10.0      4.8
  5    5.4    73.0      82    68.2   .030       .4     .4     5.41      6.1      5.1
  6    8.6   125.8     108   336.2   .060      1.6     .3     4.69      4.0     12.5
  7   31.6   114.2     441   414.1  0.000      0.0     .8     2.84     11.0     10.3
  8    8.5   131.3     632   452.9   .040      1.8     .2     2.98     14.4     10.3
  9    6.1   223.2    3197   345.4  0.000      0.0     .1     4.52     64.8      7.0
 10    6.3   391.5   10732   161.9  0.000      0.0     .1     7.29    199.9      3.0
 11    1.4    67.9     202     1.7   .020      0.0      R        R        R        R
 12    2.7  1443.7     105      .3   .120      0.0      R        R        R        R
 13   22.0   577.3   18195   342.4   .025      2.8     .2     5.17    162.9      3.1
 14    9.0   380.3    5749   944.9   .055      5.6     .1     3.70     56.0      9.2
 15    9.4    61.8     472  1293.1   .035      3.2     .1      .67      5.2     14.1
 16    6.3    41.4     633  1114.1   .060      5.0     .1      .49      7.6     13.3
 17    6.8   180.5    1077   952.9   .060      3.4     .1     3.23     19.3     17.1
 18    4.1    93.0     738   355.7  0.000      0.0     .1     3.32     26.3     12.7
 19    5.5    53.7     444   190.3   .065      1.3     .3     2.67     22.1      9.4
 20    5.2    19.4     242    83.4  0.000      0.0     .6     2.21     27.7      9.5
 21    2.2    10.9     205    42.1  0.000      0.0    1.0     5.00     93.6     22.0
 22    1.0    77.3      91     1.5   .080      0.0      R        R        R        R
 23    6.4   902.3      89      .3   .060      0.0      R        R        R        R

CYCLE COMPOSITE      HC     12.362    GRAM/BHP HR
                     CO     3[illegible].[illegible]10    GRAM/BHP HR
                     NO2    11.093    GRAM/BHP HR
                     ALDE     .196    GRAM/BHP HR
                     BSFC     .719      LB/BHP HR
```

```
                              PROJECT 11-2877-01  CONTROL TECHNOLOGY
     4-28-72 RUN 1                         ENGINE 1-3             STATIONARY DYNAMOMETER
------------------------------------------------------------------------------------------------
               DYNA.            MAN.    FUEL RATE                  DRY CONCENTRATION
MODE SPEED     LOAD     HP   VAC. LB/HR   GM/HR     ALDE.      HC        CO        CO2       NO
------------------------------------------------------------------------------------------------
   1   600       0.0     0   18.5    4.9    2228        25    8902      .470      11.72       24
   2  1200       4.6     1   19.2    9.2    4155        28    1912      .180      13.33      147
   3  1200      18.4     4   18.5    9.5    4314        31    1515      .130      13.06      225
   4  1200      41.4     9   17.0   10.8    4892        50    1740      .100      13.18      385
   5  1200      57.5    13   15.7   12.0    5424        71    1853      .100      13.18      620
   6  1200     115.0    26   11.8   16.1    7283        53    2476      .100      13.48     1850
   7  1200     172.5    39    4.2   23.9   10841       164    1522      .180      13.63     1725
   8  1200     188.5    43    1.0   24.8   11261        61    1806      .280      13.63     1850
   9  1200     211.5    48     .7   27.7   12560        90    2490      .640      13.63     1725
  10  1200     230.0    53    0.0   35.1   15931        30    5148     5.720      11.24      663
  11   600       0.0     0   18.5    4.9    2228        25    5063      .810      12.71       32
  12  1200       0.0     0   22.5    5.2    2375        49   69318      .180       3.56        3
  13  2300     250.0   109     .6   66.0   29438        37    3763     5.350      11.72      563
  14  2300     230.0   101    1.5   55.6   25220        25    2281     1.010      14.18     2200
  15  2300     205.0    90    1.8   49.4   22388        20     453      .150      14.05     2350
  16  2300     187.5    82    3.5   47.4   21503        34     339      .210      13.91     2125
  17  2300     125.0    55   11.0   33.6   15249        18    2097      .550      13.91     2750
  18  2300      62.5    27   15.5   24.1   10929        18    1586      .580      13.77     1412
  19  2300      45.0    20   16.9   21.1    9566        37    1133      .440      13.91      900
  20  2300      20.0     9   18.3   18.0    8165        27     452      .250      13.91      470
  21  2300       5.0     2   19.3   15.2    6902        15     225      .150      13.63      275
  22   600       0.0     0   18.5    4.7    2127        38    5798      .210      12.22       29
  23  2300       0.0     0   24.5    4.7    2134        44   21594      .130       2.93        3
------------------------------------------------------------------------------------------------
           CALCULATED GRAM/HR              WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2     FAC.        HP   ALDE.      HC        CO       NO2
------------------------------------------------------------------------------------------------
   1     .9  151.6     162      1.4    .070       0.0       R        R         R         R
   2    1.8   58.0     110     14.8    .060        .1     1.7    55.17     104.9      14.1
   3    2.1   49.0      85     24.2    .060        .3      .5    11.65      20.2       5.7
   4    3.9   63.3      73     46.5    .050        .5      .4     6.69       7.8       4.9
   5    6.2   74.6      81     82.9    .030        .4      .5     5.68       6.2       6.3
   6    6.0  130.4     106    323.5    .060       1.6      .2     4.96       4.0      12.3
   7   27.5  118.2     282    444.7   0.000       0.0      .7     3.00       7.2      11.3
   8   10.4  144.3     452    490.8    .040       1.7      .2     3.35      10.5      11.4
   9   16.7  215.4    1118    495.4   0.000       0.0      .3     4.46      23.1      10.3
  10    5.8  469.3   19534    200.5   0.000       0.0      .1     8.93     200.4       3.8
  11     .9   80.4     260      1.7    .020       0.0       R        R         R         R
  12    2.3 1542.4      81       .2    .120       0.0       R        R         R         R
  13   13.8  645.8   18545    320.5    .025       2.7      .1     5.90     169.4       2.9
  14    9.0  373.1    3337   1194.7    .055       5.5      .1     3.70      33.1      11.9
  15    6.7   71.1     476   1226.2    .035       3.1      .1      .79       5.3      13.7
  16   11.0   51.5     644   1021.8    .060       4.9      .1      .63       7.8      13.1
  17    4.0  218.0    1155    949.1    .060       3.3      .1     3.98      21.1      17.3
  18    2.9  119.5     883    353.2   0.000       0.0      .1     4.36      32.2      12.9
  19    5.3   74.9     588    197.6    .065       1.3      .3     3.80      29.8      10.0
  20    3.4   26.0     290     89.7   0.000       0.0      .4     2.97      33.1      10.2
  21    1.6   11.3     152     45.7   0.000       0.0      .7     5.15      69.2      20.9
  22    1.3   94.8      69      1.6    .080       0.0       R        R         R         R
  23    3.9  882.8     107       .3    .060       0.0       R        R         R         R

CYCLE COMPOSITE      HC     13.685    GRAM/BHP HR
                     CO     35.581    GRAM/BHP HR
                     NO2    11.709    GRAM/BHP HR
                     ALDE     .176    GRAM/BHP HR
                     BSFC     .733      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
    4-28-72 RUN 2                         ENGINE 1-3          STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------------
                 DYNA.          MAN.   FUEL  RATE               DRY CONCENTRATION
MODE SPEED       LOAD     HP    VAC. LB/HR   GM/HR    ALDE.     HC       CO       CO2     NO
-------------------------------------------------------------------------------------
  1    600        0.0      0    18.5    4.9    2228      27   9511     .440      9.64     25
  2   1200        4.6      1    19.3    9.2    4155      23   1668     .210     11.92    135
  3   1200       18.4      4    18.5    9.5    4314      31   1503     .130     12.09    215
  4   1200       41.4      9    16.9   10.8    4892      44   1722     .100     11.92    325
  5   1200       57.5     13    16.0   12.0    5424      68   1955     .100     12.59    580
  6   1200      115.0     26    11.9   16.1    7283      85   2569     .070     12.59   1875
  7   1200      172.5     39     4.3   23.9   10841     175   1677     .150     12.59   1688
  8   1200      188.5     43     1.1   24.8   11261      51   1846     .250     12.59   1700
  9   1200      211.5     48      .6   27.7   12560      57   2532     .740     12.82   1725
 10   1200      230.0     53     0.0   35.1   15931      28   5053    5.500     10.55    588
 11    600        0.0      0    18.5    4.9    2228      52   5692     .700     11.84     33
 12   1200        0.0      0    22.5    5.2    2375      53  54941     .150      3.81      4
 13   2300      250.0    109      .6   66.0   29938      32   4045    5.350     11.48    550
 14   2300      230.0    101     1.6   55.6   25220      23   1762     .470     14.31   2550
 15   2300      205.0     90     1.8   49.4   22388      30    339     .150     14.05   2300
 16   2300      187.5     82     3.5   47.4   21503      27    396     .250     14.05   2187
 17   2300      125.0     55    11.0   33.6   15249      30   2384     .550     14.05   2200
 18   2300       62.5     27    15.5   24.1   10929      43   1775     .610     15.09   1125
 19   2300       45.0     20    17.0   21.1    9566      37   1134     .440     14.05    688
 20   2300       20.0      9    18.3   18.0    8165      28    510     .280     14.05    400
 21   2300        5.0      2    19.2   15.2    6902      18    226     .150     13.91    230
 22    600        0.0      0    18.5    4.7    2127      29   7253     .310     12.22     24
 23   2300        0.0      0    24.5    4.7    2134      36  22570     .100      2.70      2
-------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2   FAC.      HP   ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------------
  1    1.2   192.1     179      1.7   .070     0.0      R        R        R       R
  2    1.7    56.4     143     15.1   .060      .1    1.6    53.63    136.4    14.4
  3    2.4    52.4      92     24.9   .060      .3     .6    12.46     21.9     5.9
  4    3.8    69.1      81     43.3   .050      .5     .4     7.31      8.6     4.6
  5    6.2    82.3      85     81.1   .030      .4     .5     6.27      6.5     6.2
  6   10.3   144.9      80    351.0   .060     1.6     .4     5.51      3.0    13.4
  7   31.8   140.8     254    470.6  0.000     0.0     .8     3.57      6.5    11.9
  8    9.5   159.6     437    488.0   .040     1.7     .2     3.71     10.1    11.3
  9   11.1   230.3    1359    520.2  0.000     0.0     .2     4.76     28.1    10.8
 10    5.9   486.3   10691    187.7  0.000     0.0     .1     9.25    203.4     3.6
 11    1.9    96.7     240      1.9   .070     0.0      R        R        R       R
 12    2.9  1380.0      76       .3   .120     0.0      R        R        R       R
 13   12.2   202.6   18723    317.2   .025     2.7     .1     6.42    171.5     2.9
 14    8.2   297.1    1601   1427.6   .055     5.5     .1     2.95     15.9    14.2
 15   10.2    53.4     477   1201.0   .035     3.1     .1      .59      5.3    13.4
 16    8.8    59.4     752   1088.8   .060     4.9     .1      .72      9.2    13.3
 17    6.6   245.0    1142    750.6   .060     3.3     .1     4.47     20.9    13.7
 18    6.3   122.2     848    252.1  0.000     0.0     .2     4.46     31.0     9.4
 19    5.3    74.3     582    143.5   .065     1.3     .3     3.77     29.5     7.6
 20    3.4    28.9     321     75.4  0.000     0.0     .4     3.30     36.7     8.6
 21    1.9    11.1     149     37.4  0.000     0.0     .9     5.06     67.8    17.1
 22    1.0   116.4     100      1.3   .080     0.0      R        R        R       R
 23    3.3   952.3      85       .3   .060     0.0      R        R        R       R

CYCLE COMPOSITE     HC     13.337    GRAM/BHP HR
                    CO     32.310    GRAM/BHP HR
                    NO2    11.679    GRAM/BHP HR
                    ALDE     .190    GRAM/BHP HR
                    BSFC     .733      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   5-01-72 RUN 1                   ENGINE 1-3           STATIONARY DYNAMOMETER
------------------------------------------------------------------------------
              DYNA.          MAN.   FUEL  RATE              DRY CONCENTRATION
MODE SPEED    LOAD    HP    VAC. LB/HR  GM/HR    ALDE.     HC       CO       CO2     NO
------------------------------------------------------------------------------
  1    600     0.0     0   18.8    4.9   2228        0   9084     .420    11.24     19
  2   1200     4.6     1   19.2    9.2   4155        0   1686     .210    13.18     90
  3   1200    18.4     4   18.5    9.5   4314        0   1348     .150    13.18    140
  4   1200    41.4     9   16.9   10.8   4892        0   1458     .100    13.06    260
  5   1200    57.5    13   15.8   12.0   5424        0   1683     .100    13.06    410
  6   1200   115.0    26   12.0   16.1   7283        0   2473     .100    13.33   1400
  7   1200   172.5    39    3.6   23.9  10841        0   1635     .280    13.48   1175
  8   1200   188.5    43    1.6   24.8  11261        0   1632     .250    13.33   1275
  9   1200   211.5    48     .6   27.7  12560        0   2552    1.160    13.33   1125
 10   1200   230.0    53    0.0   35.1  15931        0   4674    5.780    10.89    363
 11    600     0.0     0   18.9    4.9   2228        0   5213     .670    11.13     28
 12   1200     0.0     0   22.4    5.2   2375        0  53167     .150     3.35      4
 13   2300   250.0   109     .6   66.0  29938        0   3469    5.290    11.60    525
 14   2300   230.0   101    1.4   55.6  25220        0   1994     .890    14.18   2100
 15   2300   205.0    90    1.9   49.4  22388        0    396     .180    14.18   2250
 16   2300   187.5    82    3.4   47.4  21503        0    396     .280    14.05   2100
 17   2300   125.0    55   11.0   33.6  15249        0   2043     .660    13.91   2650
 18   2300    62.5    27   15.5   24.1  10929        0   1421     .740    14.05   1350
 19   2300    45.0    20   17.0   21.1   9566        0   1079     .520    14.18    850
 20   2300    20.0     9   18.3   18.0   8165        0    681     .390    14.18    530
 21   2300     5.0     2   19.3   15.2   6902        0    226     .180    14.05    270
 22    600     0.0     0   18.8    4.7   2127        0   8569     .180    11.24     28
 23   2300     0.0     0   24.5    4.7   2134        0  16911     .100     2.59      3
------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.      WT.  BRAKE  SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.       HC       CO     NO2
------------------------------------------------------------------------------
  1    0.0   151.0     150     1.1  .020      0.0      I        R        R       R
  2    0.0    51.7     130     9.2  .060       .1    0.0    49.15    123.7     8.7
  3    0.0    43.2      97    14.9  .060       .3    0.0    10.27     23.1     3.5
  4    0.0    53.6      74    31.7  .050       .5    0.0     5.67      7.9     3.4
  5    0.0    68.5      82    55.4  .030       .4    0.0     5.21      6.2     4.2
  6    0.0   131.7     108   247.5  .060      1.6    0.0     5.01      4.1     9.4
  7    0.0   127.3     440   303.8 0.000      0.0    0.0     3.23     11.2     7.7
  8    0.0   133.7     414   346.8  .040      1.7    0.0     3.11      9.6     8.1
  9    0.0   217.3    1996   318.2 0.000      0.0    0.0     4.50     41.3     6.6
 10    0.0   434.5   10854   111.9 0.000      0.0    0.0     8.27    206.5     2.1
 11    0.0    44.2     245     1.7  .020      0.0      I        R        R       R
 12    0.0  1431.9      82      .4  .120      0.0      I        R        R       R
 13    0.0   602.5   18559   302.7  .025      2.7    0.0     5.50    169.5     2.8
 14    0.0   329.3    2969  1151.5  .055      5.5    0.0     3.27     29.5    11.4
 15    0.0    61.6     565  1161.4  .035      3.1    0.0      .69      6.3    12.9
 16    0.0    59.3     846  1043.3  .060      4.9    0.0      .72     10.3    12.7
 17    0.0   210.8    1376   908.1  .060      3.3    0.0     3.85     25.1    16.6
 18    0.0   104.0    1094   328.0 0.000      0.0    0.0     3.80     40.0    12.0
 19    0.0    69.7     679   182.3  .065      1.3    0.0     3.54     34.4     9.3
 20    0.0    38.0     439    98.1 0.000      0.0    0.0     4.34     50.2    11.2
 21    0.0    11.0     176    43.4 0.000      0.0    0.0     5.01     80.4    19.8
 22    0.0   148.4      63     1.6  .080      0.0      I        R        R       R
 23    0.0   823.6      98      .4  .060      0.0      I        R        R       R

CYCLE COMPOSITE    HC     13.025   GRAM/BHP HR
                   CO     36.063   GRAM/BHP HR
                   NO2    10.802   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .733     LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
      5-01-72 RUN 2                       ENGINE 1-3            STATIONARY DYNAMOMETER
------------------------------------------------------------------------------------------
               DYNA.           MAN.    FUEL RATE                 DRY CONCENTRATION
MODE SPEED     LOAD     HP    VAC. LB/HR   GM/HR    ALDE.    HC      CO       CO2      NO
------------------------------------------------------------------------------------------
  1    600      0.0      0    18.7    4.9    2228       0   8799    .250    10.55      24
  2   1200      4.6      1    19.2    9.2    4155       0   1568    .180    12.82     110
  3   1200     18.4      4    18.5    9.5    4314       0   1345    .130    12.94     185
  4   1200     41.4      9    16.8   10.8    4892       0   1510    .100    12.71     370
  5   1200     57.5     13    15.8   12.0    5424       0   1678    .100    12.71     560
  6   1200    115.0     26    12.0   16.1    7283       0   2355    .070    13.06    1825
  7   1200    172.5     39     3.4   23.9   10841       0   1572    .250    13.06    1525
  8   1200    188.5     43     1.6   24.8   11261       0   1572    .250    13.06    1625
  9   1200    211.5     48      .6   27.7   12560       0   2374   1.160    12.94    1450
 10   1200    230.0     53     0.0   35.1   15931       0   4553   5.960    10.55     450
 11    600      0.0      0    18.8    4.9    2228       0   5558    .580    11.48      32
 12   1200      0.0      0    22.4    5.2    2375       0  44261    .130     3.04       3
 13   2300    250.0    109      .6   66.0   29938       0   3586   5.240    11.72     525
 14   2300    230.0    101     1.4   55.6   25220       0   2056    .930    14.42    2200
 15   2300    205.0     90     1.9   49.4   22388       0    454    .150    14.31    2400
 16   2300    187.5     82     3.4   47.4   21503       0    454    .280    14.31    2225
 17   2300    125.0     55    11.0   33.6   15249       0   2106    .640    14.31    2800
 18   2300     62.5     27    15.6   24.1   10929       0   1479    .740    14.18    1350
 19   2300     45.0     20    16.9   21.1    9566       0   1137    .550    14.31     975
 20   2300     20.0      9    18.4   18.0    8165       0    625    .390    14.42     540
 21   2300      5.0      2    19.3   15.2    6902       0    227    .180    14.31     290
 22    600      0.0      0    18.8    4.7    2127       0   4989    .150    11.60      29
 23   2300      0.0      0    24.5    4.7    2134       0  17371    .100     2.26       3
------------------------------------------------------------------------------------------
            CALCULATED GRAM/HR            WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2     FAC.       HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1   0.0    167.8       96      1.5    .070       0.0      I        R        R        R
  2   0.0     49.5      115     11.5    .060        .1    0.0    47.12    109.2     11.0
  3   0.0     43.9       86     20.1    .060        .3    0.0    10.45     20.4      4.8
  4   0.0     57.0       76     46.4    .050        .5    0.0     6.03      8.1      4.9
  5   0.0     70.1       84     77.7    .030        .4    0.0     5.34      6.4      5.9
  6   0.0    128.3       77    330.2    .060       1.6    0.0     4.88      2.9     12.6
  7   0.0    126.6      402    407.6   0.000       0.0    0.0     3.21     10.3     10.3
  8   0.0    131.5      422    451.1    .040       1.7    0.0     3.05      9.8     10.5
  9   0.0    208.0     2053    421.7   0.000       0.0    0.0     4.30     42.5      8.7
 10   0.0    427.6    11305    140.3   0.000       0.0    0.0     8.14    215.1      2.7
 11   0.0     98.1      207      1.9    .070       0.0      I        R        R        R
 12   0.0   1383.6       82       .3    .120       0.0      I        R        R        R
 13   0.0    619.9   -18297    301.3    .025       2.7    0.0     5.66    167.1      2.8
 14   0.0    333.3     3046   1184.2    .055       5.5    0.0     3.31     30.2     11.8
 15   0.0     70.0      468   1229.8    .035       3.1    0.0      .78      5.2     13.7
 16   0.0     66.7      831   1085.3    .060       4.9    0.0      .81     10.1     13.2
 17   0.0    211.8     1300    935.0    .060       3.3    0.0     3.87     23.8     17.1
 18   0.0    107.3     1084    325.1   0.000       0.0    0.0     3.92     39.6     11.9
 19   0.0     72.7      710    206.8    .065       1.3    0.0     3.69     36.0     10.5
 20   0.0     34.3      432     98.4   0.000       0.0    0.0     3.92     49.4     11.2
 21   0.0     10.8      173     45.8   0.000       0.0    0.0     4.93     79.0     20.9
 22   0.0     86.6       53      1.7    .080       0.0      I        R        R        R
 23   0.0    904.7      105       .5    .060       0.0      I        R        R        R

CYCLE COMPOSITE    HC      12.881    GRAM/BHP HR
                   CO      35.318    GRAM/BHP HR
                   NO2     11.626    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .733      LB/BHP HR
```

APPENDIX F

EMISSION RESULTS FROM ENGINE 2-3

TABULAR FORM

ENGINE 2-3

NINE MODE FTP EMISSION RESULTS

CONCENTRATION BASIS

```
        5-12-72     2-3              RUN-1                                  K =1.129      HUM = 120  GR/LB
        -----------------------------------------------------  ----------------------------------------------------------
        FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D   WEIGHTING        W E I G H T E D
        MODE            HC     CO     CO2    NO      FACTOR       HC     CO    NO     FACTOR          HC      CO       NO
        ---------------------------  ------------------------------------------------------------  -------------------
CYCLE 1
        1 IDLE          165  1.610  14.360   103      .945        156  1.522    97    .036          5.614   .055     3.504
        2 16'HG          69   .230  13.750   876     1.040         72   .239   911    .089          6.388   .021    81.099
        3 10'HG          44   .200  13.580  1340     1.056         46   .211  1415    .257         11.944   .054   363.759
        4 16'HG          39   .210  13.630   918     1.052         41   .221   966    .089          3.653   .020    85.989
        5 19 HG          31   .210  13.910   439     1.032         32   .217   453    .047          1.504   .010    21.296
        6 16'HG          44   .220  13.840  1060     1.036         46   .228  1098    .089          4.057   .020    97.727
        7  3'HG         106  1.580  14.310  1905      .953        101  1.506  1816    .283         28.589   .426   513.798
        8 16'HG          35   .270  13.770  1108     1.040         36   .281  1152    .089          3.239   .025   102.553
        9 C.T.         1862  1.470   7.150   102     1.465       2726  2.154   149    .021         57.294   .045     3.139
        SUM-----------(CYCLE COMPOSITE)-- - ---------------------------------------------------  122.282   .677  1272.863
CYCLE 2
        1 IDLE          165  1.610  14.360   103      .945        156  1.522    97    .036          5.614   .055     3.504
        2 16'HG          56   .240  13.630   854     1.050         59   .252   897    .089          5.233   .022    79.801
        3 10'HG          44   .220  13.890  1606     1.036         46   .228  1664    .257         11.714   .059   427.559
        4 16'HG          39   .220  13.910  1089     1.031         40   .227  1123    .089          3.579   .020    99.939
        5 19'HG          27   .220  14.050   478     1.022         28   .225   488    .047          1.297   .011    22.958
        6 16'HG          35   .220  13.830  1054     1.040         36   .229  1096    .089          3.238   .020    97.520
        7  3'HG         107  1.700  14.310  2033      .949        102  1.614  1930    .283         28.744   .457   546.128
        8 16'HG          35   .280  14.050  1223     1.019         36   .285  1246    .089          3.175   .025   110.929
        9 C.T.         1857  1.530   8.990   129     1.244       2309  1.903   160    .021         48.493   .040     3.369
        SUM-----------(CYCLE COMPOSITE)--------- ------------------------------------------------  111.086   .709  1391.707
CYCLE 3
        1 IDLE          144   .740  14.760    90      .949        137   .702    85    .036          4.918   .025     3.073
        2 16'HG          61   .250  13.770  1037     1.039         63   .260  1077    .089          5.639   .023    95.857
        3 10'HG          44   .230  13.910  1677     1.030         45   .237  1728    .257         11.652   .061   444.081
        4 16'HG          39   .240  13.910  1145     1.030         40   .247  1180    .089          3.577   .022   105.004
        5 19'HG          26   .240  14.050   463     1.021         27   .245   473    .047          1.248   .012    22.224
        6 16'HG          39   .240  13.840  1164     1.036         40   .249  1205    .089          3.594   .022   107.280
        7  3'HG         106  1.590  14.350  2098      .950        101  1.511  1994    .283         28.505   .428   564.183
        8 16'HG          35   .280  13.910  1238     1.029         36   .288  1274    .089          3.206   .026   113.406
        9 C.T.         1731  1.290   9.070   125     1.252       2167  1.615   156    .021         45.500   .034     3.286
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------  107.837   .652  1458.393
CYCLE 4
        1 IDLE          144   .740  14.760    90      .949        137   .702    85    .036          4.918   .025     3.073
        2 16'HG          61   .260  13.840  1025     1.033         63   .269  1059    .089          5.609   .024    94.242
        3 10'HG          44   .240  13.820  1618     1.037         46   .249  1677    .257         11.722   .064   431.061
        4 16'HG          44   .250  13.820  1071     1.036         46   .259  1110    .089          4.058   .023    98.776
        5 19'HG          30   .250  13.910   439     1.031         31   .258   453    .047          1.453   .012    21.268
        6 16'HG          44   .250  13.960  1193     1.026         45   .257  1224    .089          4.018   .023   108.938
        7  3'HG          98  1.440  14.420  2135      .951         93  1.370  2031    .283         26.377   .388   574.647
        8 16'HG          35   .280  14.050  1255     1.019         36   .285  1283    .089          3.175   .025   114.195
        9 C.T.         1809  1.390   9.010    96     1.244       2250  1.729   119    .021         47.247   .036     2.507
        SUM-----------(CYCLE COMPOSITE)--------- -----------------------------------------------  108.577   .620  1448.706

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------- ---------------------------  116.684   .693  1332.285

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------------  108.207   .636  1453.550

        FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  116.684) + 0.65*(  108.207) =   111.174  PPM
                                                    CO    0.35*(     .693) + 0.65*(     .636) =      .656  PERCENT
                                                    NO    0.35*( 1332.285) + 0.65*( 1453.550) =  1411.107  PPM
                                                                                CORRECTED NO =  1592.519  PPM

        DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
 5-12-72    2- 3              RUN-2                                  K =1.137     HUM = 124  GR/LB
--------------------------------------------------------------------------------------------------------
 FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING       W E I G H T E D
 MODE            HC      CO     CO2     NO      FACTOR     HC      CO    NO      FACTOR        HC      CO       NO
--------------------------------------------------------------------------------------------------------
CYCLE 1
 1 IDLE          154  1.210  13.630     90     1.007      155  1.218     91       .036       5.582   .044     3.262
 2 16'HG          72   .210  12.820    784     1.115       80   .234    874       .089       7.146   .021    77.811
 3 10'HG          43   .210  12.710   1213     1.127       48   .237   1368       .257      12.459   .061   351.457
 4 16'HG          43   .210  12.710    881     1.127       48   .237    993       .089       4.315   .021    88.398
 5 19'HG          33   .210  13.060    386     1.098       36   .231    424       .047       1.704   .011    19.928
 6 16'HG          39   .210  12.710    919     1.128       44   .237   1036       .089       3.915   .021    92.242
 7  3'HG          97  1.540  13.470   1883     1.011       98  1.557   1903       .283      27.748   .441   538.656
 8 16'HG          35   .250  12.940   1005     1.107       39   .277   1112       .089       3.447   .025    98.983
 9 C.T.         1931  1.300   8.310    119     1.313     2535  1.707    156       .021      53.233   .036     3.281
 SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------   119.548   .680  1274.018
CYCLE 2
 1 IDLE          154  1.210  13.630     90     1.007      155  1.218     91       .036       5.582   .044     3.262
 2 16'HG          62   .210  12.940    969     1.106       69   .232   1072       .089       6.102   .021    95.371
 3 10'HG          39   .210  12.920   1488     1.110       43   .233   1651       .257      11.122   .060   424.350
 4 16'HG          38   .210  12.820   1060     1.118       42   .235   1185       .089       3.782   .021   105.501
 5 19'HG          27   .210  12.940    449     1.109       30   .233    498       .047       1.407   .011    23.404
 6 16'HG          34   .210  12.820    905     1.119       38   .235   1012       .089       3.385   .021    90.104
 7  3'HG         102  1.570  13.330   1947     1.019      104  1.600   1985       .283      29.424   .453   561.647
 8 16'HG          31   .250  12.940   1164     1.107       34   .277   1289       .089       3.054   .025   114.681
 9 C.T.         1896  1.340   8.450    158     1.300     2451  1.742    205       .021      51.474   .037     4.312
 SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------   115.333   .691  1422.632
CYCLE 3
 1 IDLE          161  1.450  13.630    156      .998      161  1.447    156       .036       5.784   .052     5.605
 2 16'HG          59   .210  12.940   1060     1.106       65   .232   1173       .089       5.808   .021   104.353
 3 10'HG          35   .210  12.820   1514     1.119       39   .235   1694       .257      10.062   .060   435.239
 4 16'HG          32   .210  12.820    986     1.119       36   .235   1103       .089       3.187   .021    98.185
 5 19'HG          25   .210  12.940    444     1.109       28   .233    493       .047       1.303   .011    23.148
 6 16'HG          33   .210  12.820    980     1.119       37   .235   1096       .089       3.286   .021    97.579
 7  3'HG          88  1.370  13.330   1870     1.028       90  1.408   1922       .283      25.592   .398   543.836
 8 16'HG          26   .250  12.940   1037     1.107       29   .277   1148       .089       2.563   .025   102.210
 9 C.T.         1837  1.240   8.450    157     1.312     2410  1.627    206       .021      50.603   .034     4.325
 SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------   108.188   .643  1414.480
CYCLE 4
 1 IDLE          161  1.450  13.630    156      .998      161  1.447    156       .036       5.784   .052     5.605
 2 16'HG          44   .210  12.820    975     1.118       49   .235   1090       .089       4.377   .021    96.993
 3 10'HG          35   .210  12.710   1438     1.128       39   .237   1622       .257      10.148   .061   416.929
 4 16'HG          35   .210  12.710   1008     1.128       39   .237   1137       .089       3.514   .021   101.209
 5 19'HG          26   .210  12.940    463     1.109       29   .233    514       .047       1.355   .011    24.136
 6 16'HG          33   .210  12.820   1025     1.119       37   .235   1147       .089       3.286   .021   102.060
 7  3'HG          79  1.300  13.330   1885     1.031       81  1.340   1943       .283      23.048   .379   549.941
 8 16'HG          26   .250  12.820   1341     1.118       29   .279   1499       .089       2.586   .025   133.396
 9 C.T.         1737  1.050   8.300    146     1.355     2354  1.423    198       .021      49.427   .030     4.154
 SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------   103.526   .621  1434.424

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------   117.440   .685  1348.325

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------   105.857   .632  1424.452

 FOUR CYCLE COMPOSITE - REPORTED VALUES -   HC    0.35*(  117.440) + 0.65*(  105.857) =   109.911  PPM
                                            CO    0.35*(     .685) + 0.65*(     .632) =      .651  PERCENT
                                            NO    0.35*( 1348.325) + 0.65*( 1424.452) =  1397.807  PPM
                                                                      CORRECTED NO =  1588.667  PPM

 DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
  5-12-72   2-3                RUN-3                                    K =1.133      HUM = 122  GR/LB
  ------------------------------------------------------------------------------------------------------
  FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION    A D J U S T E D    WEIGHTING      W E I G H T E D
  MODE             HC     CO     CO2     NO      FACTOR    HC     CO    NO      FACTOR       HC      CO        NO
  ------------------------------------------------------------------------------------------------------
CYCLE 1
  1 IDLE          182  1.050  13.330     80     1.032     188  1.084    83      .036       6.761   .039     2.972
  2 16'HG          79   .180  12.340    874     1.159      92   .209  1013      .089       8.146   .019    90.121
  3 10'HG          53   .180  12.340   1386     1.161      62   .209  1609      .257      15.817   .054   413.617
  4 16'HG          53   .180  12.160    821     1.178      62   .212   967      .089       5.557   .019    86.088
  5 19'HG          44   .180  12.340    391     1.162      51   .209   454      .047       2.403   .010    21.356
  6 16'HG          49   .180  12.220    881     1.173      57   .211  1033      .089       5.115   .019    91.963
  7  3'HG         109  1.420  12.710   2004     1.071     117  1.521  2146      .283      33.040   .430   607.445
  8 16'HG          48   .210  12.160   1217     1.177      57   .247  1433      .089       5.029   .022   127.511
  9 C.T.         1963  1.160   7.610    119     1.406    2761  1.631   167      .021      57.976   .034     3.515
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     139.844   .645  1444.587
CYCLE 2
  1 IDLE          182  1.050  13.330     80     1.032     188  1.084    83      .036       6.761   .039     2.972
  2 16'HG          62   .210  12.220    778     1.170      73   .246   910      .089       6.457   .022    81.021
  3 10'HG          45   .200  12.290   1539     1.166      52   .233  1794      .257      13.482   .060   461.071
  4 16'HG          44   .200  12.220    964     1.172      52   .234  1130      .084       4.591   .021   100.589
  5 19'HG          35   .200  12.220    458     1.173      41   .235   537      .047       1.930   .011    25.257
  6 16'HG          44   .200  11.920   1037     1.202      53   .240  1246      .089       4.705   .021   110.897
  7  3'HG         105  1.480  12.590   1834     1.079     113  1.596  1978      .283      32.050   .452   559.815
  8 16'HG          44   .230  12.220   1188     1.171      52   .269  1391      .089       4.586   .024   123.813
  9 C.T.         1841  1.200   8.050    100     1.363    2509  1.636   136      .021      52.695   .034     2.862
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     127.257   .684  1468.298
CYCLE 3
  1 IDLE          151   .900  13.480     90     1.029     155   .926    93      .036       5.593   .033     3.334
  2 16'HG          64   .210  12.090    897     1.182      76   .248  1061      .089       6.734   .022    94.387
  3 10'HG          44   .180  12.520   1446     1.146      50   .206  1656      .257      12.954   .053   425.717
  4 16'HG          43   .210  12.400    903     1.155      50   .243  1043      .089       4.421   .022    92.844
  5 19'HG          35   .210  12.470    380     1.150      40   .241   437      .047       1.891   .011    20.532
  6 16'HG          44   .210  12.470   1071     1.149      51   .241  1230      .089       4.498   .021   109.497
  7  3'HG         111  1.770  13.060   1897     1.031     114  1.825  1956      .283      32.385   .516   553.459
  8 16'HG          47   .250  12.940   1437     1.106      52   .276  1589      .089       4.624   .025   141.391
  9 C.T.         1888  1.230   8.320    145     1.321    2495  1.625   192      .021      52.387   .034     4.023
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     125.488   .738  1445.184
CYCLE 4
  1 IDLE          151   .900  13.480     90     1.029     155   .926    93      .036       5.593   .033     3.334
  2 16'HG          61   .210  12.650   1033     1.131      69   .238  1168      .089       6.140   .021   103.978
  3 10'HG          35   .190  12.400   1291     1.157      40   .220  1494      .257      10.407   .056   383.866
  4 16'HG          39   .190  12.710   1117     1.129      44   .214  1261      .089       3.918   .019   112.203
  5 19'HG          31   .160  12.710    410     1.131      35   .181   464      .047       1.647   .009    21.789
  6 16'HG          43   .190  12.650   1100     1.134      49   .215  1247      .089       4.338   .019   110.977
  7  3'HG         102  1.380  13.180   1877     1.037     106  1.431  1947      .283      29.939   .405   550.943
  8 16'HG          39   .230  12.780   1038     1.121      44   .258  1163      .089       3.890   .023   103.542
  9 C.T.         1842  1.090   8.440     92     1.321    2434  1.440   122      .021      51.109   .030     2.553
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     116.982   .616  1393.184

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------------     133.551   .665  1456.442

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------     121.235   .677  1419.184

  FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  133.551) + 0.65*(  121.235) =   125.545  PPM
                                              CO    0.35*(     .665) + 0.65*(     .677) =      .673  PERCENT
                                              NO    0.35*( 1456.442) + 0.65*( 1419.184) =  1432.224  PPM
                                                                     CORRECTED NO =  1622.168  PPM

  DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

ENGINE 2-3

NINE MODE FTP EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
     5-12-72    2-3               RUN-1                                  K = 1.10     HUM = 120  GR/LB
     ---------------------------------------------------------------------------------------------------------------
     MASS          CONCENTRATION AS MEASURED     TOTAL    FUEL     ADJUSTED (MASS)      WT.       WEIGHTED (MASS)
     MODE           HC     CO     CO2     NO    CARBON   CONS.     HC     CO    NO2    FACT.     HC     CO   NO2(K)  HP
     ---------------------------------------------------------------------------------------------------------------

CYCLE 1
     1 IDLE        165  1.610  14.36    103   16.148    1771     20    357      4   .232     4.5     83      .9    0
     2 16 HG        69   .230  13.75    876   14.055    8308     44    275    172   .077     3.4     21    13.2   23
     3 10 HG        44   .200  13.58   1340   13.828   12939     44    378    416   .147     6.5     56    61.2   48
     4 16 HG        39   .210  13.63    918   13.882    8308     25    254    182   .077     1.9     20    14.0   23
     5 19 HG        31   .210  13.91    439   14.153    5924     14    178     61   .057      .8     10     3.5    9
     6 16 HG        44   .220  13.84   1060   14.108    8308     28    262    207   .077     2.2     20    16.0   23
     7  3 HG       106  1.580  14.31   1905   16.004   21656    155   4319    856   .113    17.5    488    96.7   86
     8 16 HG        35   .270  13.77   1108   14.028    8308     22    322    217   .077     1.7     25    16.7   23
     9 C.T.       1862  1.470   7.15    102   10.641    1771    335    445      6   .143    47.9     71      .8    0
     SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.6     33     4.2

CYCLE 2
     1 IDLE        165  1.610  14.36    103   16.148    1771     20    357      4   .232     4.5     83      .9    0
     2 16 HG        56   .240  13.63    854   13.930    8308     36    289    169   .077     2.8     22    13.0   23
     3 10 HG        44   .220  13.84   1606   14.108   12939     44    408    489   .147     6.4     60    71.9   48
     4 16 HG        39   .220  13.91   1089   14.172    8308     25    261    212   .077     1.9     20    16.3   23
     5 19 HG        27   .220  14.05    478   14.299    5924     12    184     66   .057      .7     10     3.7    9
     6 16 HG        35   .220  13.80   1054   14.058    8308     22    263    207   .077     1.7     20    15.9   23
     7  3 HG       107  1.700  14.31   2033   16.126   21656    155   4612    906   .113    17.5    521   102.4   86
     8 16 HG        35   .280  14.05   1223   14.368    8308     22    327    235   .077     1.7     25    18.1   23
     9 C.T.       1857  1.530   8.89    129   12.426    1771    286    440      6   .143    40.9     63      .9    0
     SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.2     34    10.0

CYCLE 3
     1 IDLE        144   .740  14.76     90   15.656    1771     18    169      3   .232     4.1     39      .8    0
     2 16 HG        61   .250  13.77   1037   14.086    8308     39    298    203   .077     3.0     23    15.6   23
     3 10 HG        44   .230  13.91   1677   14.188   12939     43    424    508   .147     6.4     62    74.6   48
     4 16 HG        39   .240  13.91   1145   14.192    8308     25    284    223   .077     1.9     22    17.1   23
     5 19 HG        26   .240  14.05    463   14.318    5924     12    201     64   .057      .7     11     3.6    9
     6 16 HG        39   .240  13.84   1164   14.122    8308     25    285    227   .077     1.9     22    17.5   23
     7  3 HG       106  1.590  14.35   2098   16.054   21656    154   4332    940   .113    17.4    490   106.2   86
     8 16 HG        35   .280  13.91   1238   14.228    8308     22    330    240   .077     1.7     25    18.5   23
     9 C.T.       1731  1.290   9.07    125   12.229    1771    271    377      6   .143    38.7     54      .9    0
     SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.1     31    10.5

CYCLE 4
     1 IDLE        144   .740  14.76     90   15.656    1771     18    169      3   .232     4.1     39      .8    0
     2 16 HG        61   .260  13.84   1025   14.166    8308     39    308    200   .077     3.0     24    15.4   23
     3 10 HG        44   .240  13.82   1618   14.108   12939     44    445    493   .147     6.4     65    72.4   48
     4 16 HG        44   .250  13.82   1071   14.118    8308     28    297    209   .077     2.2     23    16.1   23
     5 19 HG        30   .250  13.91    439   14.192    5924     14    211     61   .057      .8     12     3.5    9
     6 16 HG        44   .250  13.96   1193   14.258    8308     28    294    231   .077     2.1     23    17.8   23
     7  3 HG        98  1.440  14.42   2135   15.966   21656    144   3945    961   .113    16.2    446   108.6   86
     8 16 HG        35   .280  14.05   1259   14.368    8308     22    327    242   .077     1.7     25    18.6   23
     9 C.T.       1809  1.390   9.01     96   12.354    1771    280    403      5   .143    40.1     58      .7    0
     SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.1     24    10.4

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------     3.4     33     9.6

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------     3.1     30    10.5

     FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.4) + 0.65(     3.1) =    3.220  (MASS)
                                              CO  0.35(      33) + 0.65(      30) =     31.2  (MASS)
                                              NO2 0.35(     9.6) + 0.65(    10.5) =   10.154  (MASS)
                                                               CORRECTED NO2 =   11.161  (MASS)
```

```
5-12-72    2-3                RUN-2                                             K = 1.10     HUM = 124  GR/LB
-------------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED     TOTAL    FUEL       ADJUSTED (MASS)        WT.        WEIGHTED (MASS)
MODE           HC      CO     CO2     NO   CARBON   CONS.      HC      CO     NO2    FACT.       HC       CO   NO2(K)  HP
-------------------------------------------------------------------------------------------------------------------

CYCLE 1
      1 IDLE      154   1.210   13.63      90   15.006    1771       20     284       4   .232      4.6       67      .8    0
      2 16 HG      72    .210   12.82     784   13.108    8308       49     269     165   .077      3.8       21    12.7   23
      3 10 HG      41    .210   12.71    1213   12.466   12439       46     423     402   .147      6.8       62    59.1   48
      4 16 HG      43    .210   12.71     881   12.966    8308       30     272     187   .077      2.3       21    14.4   23
      5 19 HG      33    .210   13.06     386   13.306    5924       16     189      57   .057       .9       11     3.3    9
      6 16 HG      39    .210   12.71     919   12.962    8308       27     272     196   .077      2.1       21    15.1   23
      7  3 HG      47   1.540   13.47    1883   15.115   21656      150    4457     896   .113     17.0      504   101.2   86
      8 16 HG      35    .250   12.94    1005   13.228    8308       24     317     210   .077      1.8       24    16.1   23
      9 C.T.     1931   1.300    8.31     119   11.645    1771      316     398       6   .143     45.2       57      .9    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.5       32     9.2

CYCLE 2
      1 IDLE      154   1.210   13.63      90   15.006    1771       20     288       4   .232      4.6       67      .8    0
      2 16 HG      62    .210   12.94     969   13.217    8308       42     267     202   .077      3.2       21    15.6   23
      3 10 HG      34    .210   12.92    1488   13.172   12439       41     417     485   .147      6.1       61    71.3   48
      4 16 HG      38    .210   12.82    1060   13.071    8308       26     270     224   .077      2.0       21    17.2   23
      5 19 HG      27    .210   12.94     449   13.179    5924       13     191      67   .057       .7       11     3.8    9
      6 16 HG      34    .210   12.82     905   13.067    8308       23     270     191   .077      1.8       21    14.7   23
      7  3 HG     102   1.570   13.33    1947   15.010   21656      159    4576     933   .113     18.0      517   105.4   86
      8 16 HG      31    .250   12.94    1164   13.223    8308       21     317     243   .077      1.6       24    18.7   23
      9 C.T.     1886   1.340    8.45     158   11.827    1771      305     405       8   .143     43.6       58     1.1    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.4       33    10.2

CYCLE 3
      1 IDLE      161   1.450   13.63     156   15.254    1771       20     340       6   .232      4.7       74     1.4    0
      2 16 HG      59    .210   12.94    1060   13.214    8308       40     267     221   .077      3.1       21    17.0   23
      3 10 HG      35    .210   12.82    1514   13.068   12939       37     420     498   .147      5.5       62    73.2   48
      4 16 HG      32    .210   12.82     986   13.065    8308       22     270     208   .077      1.7       21    16.0   23
      5 19 HG      25    .210   12.94     444   13.177    5924       12     191      66   .057       .7       11     3.8    9
      6 16 HG      33    .210   12.82     980   13.066    8308       23     270     207   .077      1.7       21    15.9   23
      7  3 HG      88   1.370   13.33    1870   14.795   21656      139    4051     909   .113     15.7      458   102.7   86
      8 16 HG      26    .250   12.94    1037   13.218    8308       18     317     216   .077      1.4       24    16.7   23
      9 C.T.     1837   1.240    8.45     157   11.674    1771      301     380       8   .143     43.0       54     1.1    0
      SUM------------(CYCLF COMPOSITE)----------------------------------------------------      3.2       31    10.2

CYCLE 4
      1 IDLE      161   1.450   13.63     156   15.254    1771       20     340       6   .232      4.7       79     1.4    0
      2 16 HG      44    .210   12.82     975   13.078    8308       30     269     206   .077      2.3       21    15.8   23
      3 10 HG      35    .210   12.71    1438   12.958   12939       38     424     477   .147      5.5       62    70.1   48
      4 16 HG      35    .210   12.71    1008   12.958    8308       24     272     215   .077      1.9       21    16.5   23
      5 19 HG      26    .210   12.94     463   13.178    5924       13     191      69   .057       .7       11     3.9    9
      6 16 HG      33    .210   12.82    1025   13.066    8308       23     270     216   .077      1.7       21    16.7   23
      7  3 HG      79   1.300   13.33    1885   14.715   21656      126    3865     921   .113     14.2      437   104.1   86
      8 16 HG      26    .250   12.82    1341   13.098    8308       18     320     282   .077      1.4       25    21.7   23
      9 C.T.     1737   1.050    8.30     146   11.226    1771      296     335       8   .143     42.3       48     1.1    0
      SUM------------(CYCLE COMPOSITE)----------------------------------------------------      3.1       30    10.3

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------      3.4       33     9.7

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------      3.1       30    10.3

      FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.4) + 0.65(     3.1) =     3.230  (MASS)
                                               CO  0.35(      33) + 0.65(      30) =      31.1  (MASS)
                                               NO2 0.35(     9.7) + 0.65(    10.3) =    10.071  (MASS)
                                                                 CORRECTED NO2 =    11.114  (MASS)
```

```
        5-12-72   2-3              RUN-3                                     K = 1.10     HUM = 122  GR/LB
        -----------------------------------------------------------------------------------------------------------------
        MASS        CONCENTRATION AS MEASURED      TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
        MODE          HC     CO     CO2      NO    CARBON   CONS.      HC     CO    NO2     FACT.      HC      CO  NO2(K)  HP
        -----------------------------------------------------------------------------------------------------------------

CYCLE 1
        1 IDLE       182  1.050  13.33      80   14.577    1771       24    258      3    .232      5.5      60     .7    0
        2 16 HG       79   .180  12.34     874   12.605    8308       56    240    191    .077      4.3      18   14.7   23
        3 10 HG       53   .180  12.34    1526   12.577   12939       59    374    473    .147      8.7      55   69.6   48
        4 16 HG       53   .180  12.16     821   12.397    8308       38    244    183    .077      3.0      19   14.1   23
        5 19 HG       44   .180  12.34     391   12.568    5924       22    171     61    .057      1.3      10    3.5    9
        6 16 HG       49   .180  12.22     881   12.453    8308       35    243    195    .077      2.7      19   15.0   23
        7  3 HG      109  1.420  12.71    2004   14.248   21656      179   4360   1011    .113     20.2     493  114.3   86
        8 16 HG       48   .210  12.16    1217   12.422    8308       35    284    270    .077      2.7      22   20.8   23
        9 C.T.      1963  1.160   7.61     119   10.890    1771      345    381      6    .143     49.3      54     .9    0
        SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------       4.0      31   10.4

CYCLE 2
        1 IDLE       182  1.050  13.33      80   14.577    1771       24    258      3    .232      5.5      60     .7    0
        2 16 HG       62   .210  12.22     778   12.497    8308       45    282    172    .077      3.4      22   13.2   23
        3 10 HG       45   .200  12.29    1539   12.539   12939       50    417    527    .147      7.4      61   77.5   48
        4 16 HG       44   .200  12.22     964   12.468    8308       32    269    213    .077      2.4      21   16.4   23
        5 19 HG       35   .200  12.22     458   12.458    5924       18    192     72    .057      1.0      11    4.1    9
        6 16 HG       44   .200  11.92    1037   12.168    8308       32    276    235    .077      2.5      21   18.1   23
        7  3 HG      105  1.480  12.59    1834   14.183   21656      173   4565    930    .113     19.6     516  105.1   86
        8 16 HG       44   .230  12.22    1188   12.498    8308       32    309    262    .077      2.4      24   20.2   23
        9 C.T.      1841  1.200   8.05     100   11.238    1771      313    382      5    .143     44.8      55     .7    0
        SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------       3.7      32   10.5

CYCLE 3
        1 IDLE       151   .900  13.48      90   14.543    1771       20    221      4    .232      4.6      51     .8    0
        2 16 HG       64   .210  12.09     897   12.369    8308       46    285    200    .077      3.6      22   15.4   23
        3 10 HG       44   .180  12.52    1446   12.748   12939       48    369    487    .147      7.1      54   71.6   48
        4 16 HG       43   .210  12.40     903   12.656    8308       30    278    197    .077      2.3      21   15.2   23
        5 19 HG       35   .210  12.47     380   12.718    5924       18    198     54    .057      1.0      11    3.3    9
        6 16 HG       44   .210  12.47    1071   12.728    8308       31    277    232    .077      2.4      21   17.9   23
        7  3 HG      111  1.770  13.06    1897   14.950   21656      174   5179    912    .113     19.6     585  103.1   86
        8 16 HG       47   .250  12.94    1437   13.241    8308       32    317    299    .077      2.5      24   23.0   23
        9 C.T.      1888  1.230   8.32     145   11.589    1771      312    380      7    .143     44.6      54    1.1    0
        SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------       3.6      35   10.3

CYCLE 4
        1 IDLE       151   .900  13.48      90   14.543    1771       20    221      4    .232      4.6      51     .8    0
        2 16 HG       61   .210  12.65    1033   12.926    8308       42    273    220    .077      3.3      21   17.0   23
        3 10 HG       35   .190  12.40    1291   12.628   12939       39    393    439    .147      5.7      58   64.6   48
        4 16 HG       39   .190  12.71    1117   12.942    8308       27    246    238    .077      2.1      19   18.3   23
        5 19 HG       31   .160  12.71     410   12.903    5924       15    148     62    .057       .9       8    3.6    9
        6 16 HG       43   .190  12.65    1100   12.886    8308       30    247    235    .077      2.3      19   18.1   23
        7  3 HG      102  1.380  13.18    1877   14.670   21656      163   4115    920    .113     18.4     465  103.9   86
        8 16 HG       39   .230  12.78    1038   13.052    8308       27    296    219    .077      2.1      23   16.9   23
        9 C.T.      1842  1.090   8.44      92   11.519    1771      306    339      5    .143     43.7      48     .7    0
        SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------       3.4      29   10.0

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------------       3.8      32   10.5

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------------       3.5      32   10.2

        FOUR CYCLE COMPOSITE - REPORTED VALUFS - HC  0.35(     3.8) + 0.65(     3.5) =    3.625  (MASS)
                                                 CO  0.35(      32) + 0.65(      32) =     31.9  (MASS)
                                                 NO2 0.35(    10.5) + 0.65(    10.2) =   10.290  (MASS)
                                                                   CORRECTED NO2 =   11.334  (MASS)
```

ENGINE 2-3

EXPERIMENTAL 23 MODE EMISSION RESULTS

BRAKE SPECIFIC BASIS

```
                        PROJECT 11-2677-01  CONTROL TECHNOLOGY
  5-11-72 RUN 1                    ENGINE 2-3          STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------
               DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED     LOAD    HP  VAC. LB/HR  RATIO    ALDE.    HC       CO       CO2      NO
-------------------------------------------------------------------------------
  1    600      0.0     0  18.5    4.3                 25   3349  1.010    13.62     47
  2   1200      4.4     1  19.1    7.5                 27    955   .150    13.15    100
  3   1200     17.6     4  18.8    7.9                 44   1457   .150    12.90    215
  4   1200     39.6     9  17.3    9.2                 77   1788   .130    12.55    470
  5   1200     55.0    13  16.2   10.0                 75   1952   .130    12.35    600
  6   1200    110.0    25   9.8   15.2                 76   1336   .130    12.10    913
  7   1200    165.0    38   6.4   20.1                 86   2027   .210    13.40   2000
  8   1200    180.4    41   4.7   21.8                 64   1914   .350    13.25   2200
  9   1200    202.4    46   1.7   24.2                 87   2144   .250    13.63   2500
 10   1200    220.0    50   0.0   31.6                 55   3955  5.030    10.80    450
 11    600      0.0     0  18.6    4.3                 32   3509  1.550    12.73     48
 12   1200      0.0     0  23.0    4.1                166  73417   .640     6.28      6
 13   2300    235.0   103   1.8   50.9                 57   2453  1.450    13.77   2300
 14   2300    216.2    95   3.4   47.8                 58   1821  1.160    13.77   2100
 15   2300    192.7    84   5.3   43.4                 56   1648  1.160    13.63   2050
 16   2300    176.2    77   6.8   39.5                 38   1698   .630    13.63   2100
 17   2300    117.5    51  11.2   27.9                 60    560   .210    12.71   2100
 18   2300     58.8    26  16.6   19.2                 59    560   .220    12.71    850
 19   2300     42.3    19  17.8   16.5                 65    470   .220    12.59    525
 20   2300     18.8     8  19.4   14.3                 38    358   .200    12.47    290
 21   2300      4.7     2  20.7   12.1                 25    308   .200    12.59    169
 22    600      0.0     0  18.5    4.3                 33   3617   .770    13.33     37
 23   2300      0.0     0  24.9    4.2                 81  43892   .420     4.45      4
-------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.     HC       CO      NO2
-------------------------------------------------------------------------------
  1     .7    43.5     265     2.0   .070      0.0     R        R        R       R
  2    1.5    24.3      77     8.4   .060       .1   1.5    24.16     76.7     8.4
  3    2.6    34.7      83    19.5   .060       .2    .6     9.88     20.5     4.8
  4    5.4    57.9      85    50.5   .050       .5    .6     6.40      4.4     5.6
  5    5.8    69.9      94    71.4   .030       .4    .5     5.57      7.5     5.7
  6    9.2    74.6     147   169.1   .060      1.5    .4     2.97      5.8     6.7
  7   12.3   133.8     280   438.5  0.000      0.0    .3     3.55      7.4    11.6
  8    9.9   137.1     506   523.1   .040      1.6    .2     3.33     12.3    12.7
  9   14.7   166.8     393   645.6  0.000      0.0    .3     3.61      8.5    14.0
 10   10.5   349.0    8965   131.8  0.000      0.0    .2     6.94    178.4     2.6
 11     .9    46.6     416     2.1   .070      0.0     R        R        R       R
 12    4.6   952.0     168      .3   .120      0.0     R        R        R       R
 13   18.3   366.4    4375  1140.6   .025      2.6    .2     3.56     42.5    11.1
 14   18.1   261.3    3362  1000.4   .055      5.2    .2     2.76     35.5    10.6
 15   16.0   217.1    3087   896.6   .035      3.0    .2     2.57     36.6    10.6
 16   10.3   210.7    1579   865.2   .060      4.6    .1     2.73     20.5    11.2
 17   12.7    54.6     414   680.4   .060      3.1    .2     1.06      8.0    13.2
 18    8.6    37.5     298   189.0  0.000      0.0    .3     1.46     11.6     7.3
 19    8.1    27.3     258   101.3   .065      1.2    .4     1.47     13.9     5.5
 20    4.2    18.2     206    49.1  0.000      0.0    .5     2.21     25.0     6.0
 21    2.3    13.2     173    24.0  0.000      0.0   1.1     6.39     84.0    11.6
 22     .9    48.6     209     1.7   .080      0.0     R        R        R       R
 23    3.6   899.0     174      .3   .060      0.0     R        R        R       R

CYCLE COMPOSITE     HC     10.274   GRAM/BHP HR
                    CO     28.372   GRAM/BHP HR
                    NO2    10.530   GRAM/BHP HR
                    ALDE     .272   GRAM/BHP HR
                    BSFC     .655     LB/BHP HR
```

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
   5-15-72 RUN 1               ENGINE 2-3            STATIONARY DYNAMOMETER
------------------------------------------------------------------------------
               DYNA.         MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR   RATIO   ALDE.     HC       CO      CO2     NO
------------------------------------------------------------------------------
  1    600      0.0     0   18.5   3.8              39   3071     .930    13.91     44
  2   1200      4.5     1   19.1   7.2              40    729     .150    13.06     98
  3   1200     17.9     4   18.7   7.7              48   1122     .150    13.06    185
  4   1200     40.3     9   17.4   9.0              93   1459     .150    13.06    420
  5   1200     56.0    13   16.2  10.1              67   1850     .150    12.94    750
  6   1200    112.0    26   14.0  11.3              63   1287     .150    12.71   1025
  7   1200    168.0    38   15.5  21.0              83   1698     .350    13.91   2000
  8   1200    184.0    42    4.0  22.7              76   1641     .470    13.77   2200
  9   1200    206.0    47    2.5  24.2              79   1983     .350    14.05   2450
 10   1200    224.0    51    0.0  26.7              64   3748    5.790    10.77    600
 11    600      0.0     0   19.3   3.8              50   3074    1.480    13.48     48
 12   1200      0.0     0   23.0   3.7             131  62755     .580     6.30      6
 13   2300    235.0   103    2.5  49.8              52   2108    1.590    13.48   2350
 14   2300    216.0    95    4.3  45.5              58   1593    1.450    13.48   2250
 15   2300    192.5    84    6.7  40.3              55   1880    1.590    13.48   2200
 16   2300    176.0    77    7.9  36.9              53   1585     .550    13.77   2850
 17   2300    117.5    51   11.5  27.6              46    505     .220    12.94   2350
 18   2300     58.8    26   16.7  18.5              57    471     .210    12.82   1325
 19   2300     42.3    19   18.0  16.4              60    415     .210    12.82    850
 20   2300     18.8     8   19.8  12.0              36    286     .180    12.82    400
 21   2300      4.7     2   20.8  10.1              36    235     .180    12.71    217
 22    600      0.0     0   18.8   2.8              40   2606     .880    13.48     47
 23   2300      0.0     0   25.0   3.9              85  35661     .440     4.84      4
------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC     CO     NO2   FAC.       HP  ALDE.      HC      CO     NO2
------------------------------------------------------------------------------
  1    1.0    34.6    212     1.7  .070      0.0      R       R       R       R
  2    2.1    17.9     75     8.0  .060       .1    2.1   17.52    72.8     7.8
  3    2.7    29.5     80    16.1  .060       .2     .7    7.21    19.5     3.9
  4    6.2    44.4     92    42.5  .050       .5     .7    4.83    10.0     4.6
  5    5.0    63.9    105    86.1  .030       .4     .4    5.00     8.2     6.7
  6    5.3    50.6    119   133.8  .060      1.5     .2    1.98     4.7     5.2
  7   11.9   112.3    468   439.3 0.000      0.0     .3    2.93    12.2    11.4
  8   11.7   117.4    679   522.4  .040      1.7     .3    2.79    16.2    12.4
  9   12.8   148.9    531   610.9 0.000      0.0     .3    3.16    11.3    13.0
 10    9.8   267.7   8355   142.3 0.000      0.0     .2    5.23   163.2     2.8
 11    1.2    34.4    334     1.8  .070      0.0      R       R       R       R
 12    3.6   792.1    148      .3  .120      0.0      R       R       R       R
 13   16.5   311.5   4746  1152.9  .025      2.6     .2    3.03    46.1    11.2
 14   17.1   218.0   4007  1022.0  .055      5.2     .2    2.30    42.4    10.8
 15   14.4   225.3   3849   875.2  .035      3.0     .2    2.67    45.7    10.4
 16   13.3   183.1   1283  1093.0  .060      4.6     .2    2.38    16.7    14.2
 17    9.5    47.8    421   739.6  .060      3.1     .2     .93     8.2    14.4
 18    8.0    30.3    273   283.0 0.000      0.0     .3    1.18    10.6    11.0
 19    7.3    23.5    241   160.2  .065      1.2     .4    1.27    13.0     8.6
 20    3.2    11.9    152    55.4 0.000      0.0     .4    1.45    18.4     6.7
 21    2.8     8.4    129    25.7 0.000      0.0    1.3    4.06    62.8    12.5
 22     .8    22.9    156     1.4  .080      0.0      R       R       R       R
 23    3.6   707.4    176      .3  .060      0.0      R       R       R       R

CYCLE COMPOSITE    HC      8.410   GRAM/BHP HR
                   CO     30.073   GRAM/BHP HR
                   NO2    11.308   GRAM/BHP HR
                   ALDE     .254   GRAM/BHP HR
                   BSFC     .614     LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
    5-16-72 RUN 1                         ENGINE 2-3            STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------------------
               DYNA.          MAN.  FUEL    A/F                 DRY CONCENTRATION
MODE SPEED     LOAD     HP    VAC.  LB/HR   RATIO    ALDE.     HC       CO        CO2      NO
--------------------------------------------------------------------------------------------
  1    600      0.0      0    18.8    3.9              50     3872    1.090     13.91      41
  2   1200      4.5      1    19.2    7.9              42      841     .130     12.94      91
  3   1200     17.9      4    19.0    8.0              69     1231     .130     12.71     145
  4   1200     40.3      9    17.5    9.1              63     1786     .130     12.47     370
  5   1200     56.0     13    16.3   10.3              73     1894     .130     12.22     688
  6   1200    112.0     26    11.1   15.6              78     1396     .130     12.47    1000
  7   1200    168.0     38     6.3   20.5              83     1804     .280     13.48    1750
  8   1200    184.0     42     4.5   22.5              67     1802     .490     13.18    1950
  9   1200    206.0     47     3.0   24.2              67     1927     .390     14.05    2300
 10   1200    224.0     51     0.0   32.7              42     3697    5.900     10.89     650
 11    600      0.0      0    19.4    3.6              41     3414    1.300     13.63      45
 12   1200      0.0      0    23.0    3.6             155    64831     .490      6.30       6
 13   2300    235.0    103     2.6   50.3              52     2168    1.770     13.48    2100
 14   2300    216.0     95     4.4   46.2              54     1707    1.450     13.48    2150
 15   2300    192.5     84     6.4   41.7              63     1820    1.380     13.48    2050
 16   2300    176.0     77     7.7   35.8              29     1528     .520     13.77    2350
 17   2300    117.5     51    11.8   27.1              59      504     .170     12.82    2050
 18   2300     58.8     26    16.8   18.1              47      493     .170     12.82    1025
 19   2300     42.3     19    18.0   16.6              58      436     .170     12.71     688
 20   2300     18.8      8    19.9   12.4              33      280     .160     12.71     290
 21   2300      4.7      2    20.9   11.3              27      241     .160     12.71     192
 22    600      0.0      0    18.7    3.6              42     3114     .810     13.48      38
 23   2300      0.0      0    24.9    3.8              93    40380     .440      4.84       3
--------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR             WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO      NO2     FAC.      HP   ALDE.     HC       CO      NO2
--------------------------------------------------------------------------------------------
  1    1.2    44.2     251      1.6    .070     0.0     R        R        R        R
  2    2.5    23.0      72      8.3    .060      .1    2.4    22.46     70.1      8.1
  3    4.2    34.6      74     13.5    .060      .2    1.0     8.46     18.0      3.3
  4    4.4    57.5      85     39.6    .050      .5     .5     6.25      9.2      4.3
  5    5.9    70.7      98     85.2    .030      .4     .5     5.53      7.7      6.7
  6    9.4    77.7     146    184.8    .060     1.5     .4     3.04      5.7      7.2
  7   12.0   120.5     378    388.1   0.000     0.0     .3     3.14      9.8     10.1
  8   10.7   132.8     730    477.2    .040     1.7     .3     3.16     17.4     11.3
  9   10.9   144.4     590    572.1   0.000     0.0     .2     3.07     12.5     12.2
 10    7.8   319.6   10304    186.6   0.000     0.0     .2     6.25    201.3      3.6
 11     .9    36.1     277      1.6    .070     0.0     R        R        R        R
 12    4.1   788.0     120       .2    .120     0.0     R        R        R        R
 13   16.5   319.8    5275   1028.5    .025     2.6     .2     3.11     51.3     10.0
 14   16.3   237.1    4069    991.5    .055     5.2     .2     2.51     43.0     10.5
 15   17.2   228.6    3502    855.1    .035     3.0     .2     2.71     41.5     10.1
 16    7.0   172.0    1182    878.0    .060     4.6     .2     2.23     15.3     11.4
 17   12.0    47.5     324    641.2    .060     3.1     .1      .92      6.3     12.5
 18    6.4    31.1     217    214.7   0.000     0.0     .2     1.21      8.4      8.3
 19    7.3    25.4     200    132.8    .065     1.2     .4     1.37     10.8      7.2
 20    3.1    12.2     141     42.0   0.000     0.0     .4     1.48     17.1      5.1
 21    2.3     9.5     128     25.3   0.000     0.0    1.1     4.63     62.2     12.3
 22    1.0    34.4     181      1.4    .080     0.0     R        R        R        R
 23    3.7   740.0     163       .2    .060     0.0     R        R        R        R

CYCLE COMPOSITE     HC       8.730    GRAM/BHP HR
                    CO      29.615    GRAM/BHP HR
                    NO2     10.260    GRAM/BHP HR
                    ALDE      .261    GRAM/BHP HR
                    BSFC      .630      LB/BHP HR
```

```
                     PROJECT 11-2872-01  CONTROL TECHNOLOGY
   5-16-72 RUN 2                    ENGINE 2-3          STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------------
              DYNA.         MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.    HC       CO       CO2      NO
--------------------------------------------------------------------------------------
   1   600     0.0     0   18.5   3.7    14.5       0   3141   1.050    14.31     36
   2  1200     4.5     1   19.3   7.1    16.4       0    673    .150    12.94     79
   3  1200    17.9     4   18.9   7.3    16.4       0   1121    .150    12.94    125
   4  1200    40.3     9   17.4   8.7    16.3       0   1794    .150    12.94    420
   5  1200    56.0    13   16.1  10.5    16.4       0   1790    .130    12.71    725
   6  1200   112.0    26   11.2  13.4    16.5       0   1565    .150    12.59   1250
   7  1200   168.0    38    6.5  20.8    15.1       0   1693    .310    13.63   1900
   8  1200   184.0    42    4.9  21.5    15.0       0   1865    .440    13.63   2000
   9  1200   206.0    47    3.1  23.2    14.9       0   1864    .390    13.63   2450
  10  1200   224.0    51    0.0  32.1    12.1       0   3628   5.840    10.55    600
  11   600     0.0     0   19.2   3.3    13.9       0   3699   1.870    13.06     45
  12  1200     0.0     0   23.0   3.7    14.3       0  64268    .870     6.82      5
  13  2300   235.0   103    2.6  50.5    14.1       0   2171   1.800    13.63   2250
  14  2300   216.0    95    4.5  45.9    14.2       0   1884   1.730    13.63   2150
  15  2300   192.5    84    6.5  41.2    14.2       0   1998   1.550    13.77   2100
  16  2300   176.0    77    7.4  39.3    14.6       0   1818    .650    14.05   2350
  17  2300   117.5    51   12.1  25.8    16.2       0    561    .210    13.06   2600
  18  2300    58.8    26   16.9  16.4    16.3       0    460    .210    13.06   1200
  19  2300    42.3    19   18.1  15.8    16.3       0    404    .210    13.06    788
  20  2300    18.8     8   19.8  13.1    16.3       0    281    .160    13.06    400
  21  2300     4.7     2   20.9  11.3    16.3       0    224    .160    13.06    225
  22   600     0.0     0   18.6   3.7    14.4       0   2843   1.050    13.77     45
  23  2300     0.0     0   24.9   3.6    20.2       0  34963    .470     5.96      5
--------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2   FAC.      HP  ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------------
   1   0.0    33.3     225     1.3  .070     0.0      I        R        R        R
   2   0.0    16.5      74     6.4  .060      .1    0.0    16.08     72.4      6.2
   3   0.0    28.1      76    10.4  .060      .2    0.0     6.88     18.6      2.5
   4   0.0    53.1      90    41.3  .050      .5    0.0     5.77      9.7      4.5
   5   0.0    65.7      96    88.3  .030      .4    0.0     5.13      7.5      6.9
   6   0.0    74.0     143   196.3  .060     1.5    0.0     2.89      5.6      7.7
   7   0.0   113.5     420   422.6 0.000     0.0    0.0     2.96     10.9     11.0
   8   0.0   127.3     607   453.5  .040     1.7    0.0     3.03     14.4     10.8
   9   0.0   138.3     584   603.4 0.000     0.0    0.0     2.94     12.4     12.8
  10   0.0   315.1   10248   173.0 0.000     0.0    0.0     6.16    200.2      3.4
  11   0.0    36.7     375     1.5  .070     0.0      I        R        R        R
  12   0.0   755.9     207      .2  .120     0.0      I        R        R        R
  13   0.0   317.9    5324  1093.8  .025     2.6    0.0     3.09     51.7     10.6
  14   0.0   252.5    4683   956.4  .055     5.2    0.0     2.67     49.5     10.1
  15   0.0   240.9    3774   840.5  .035     3.0    0.0     2.86     44.8     10.0
  16   0.0   217.5    1571   933.8  .060     4.6    0.0     2.82     20.4     12.1
  17   0.0    49.4     373   759.1  .060     3.1    0.0      .96      7.2     14.8
  18   0.0    25.7     236   222.1 0.000     0.0    0.0     1.00      9.2      8.6
  19   0.0    21.8     229   141.1  .065     1.2    0.0     1.18     12.4      7.6
  20   0.0    12.6     145    59.7 0.000     0.0    0.0     1.53     17.7      7.3
  21   0.0     8.7     125    28.8 0.000     0.0    0.0     4.21     60.6     14.0
  22   0.0    31.3     233     1.6  .080     0.0      I        R        R        R
  23   0.0   568.2     154      .3  .060     0.0      I        R        R        R

CYCLE COMPOSITE      HC       8.194    GRAM/BHP HR
                     CO      33.247    GRAM/BHP HR
                     NO2     10.667    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .620      LB/BHP HR
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
   5-17-72 RUN 1                    ENGINE 2-3             STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------------
            DYNA.          MAN. FUEL    A/F                 DRY CONCENTRATION
MODE SPEED  LOAD     HP   VAC. LB/HR   RATIO   ALDE.    HC       CO        CO2     NO
-------------------------------------------------------------------------------------
  1   600     0.0     0   18.7   4.4    14.5       0   3857   1.050     13.48     38
  2  1200     4.5     1   19.2   7.7    16.4       0    785    .210     12.44     95
  3  1200    17.9     4   18.8   7.8    16.5       0   1120    .150     12.82    130
  4  1200    40.3     9   17.4   9.4    16.4       0   1792    .150     12.82    480
  5  1200    56.0    13   16.5  10.0    16.4       0   1848    .150     12.82    625
  6  1200   112.0    26   10.3  15.4    16.8       0   1508    .150     12.47   1075
  7  1200   168.0    38    6.2  20.5    15.2       0   1807    .390     13.63   1950
  8  1200   184.0    42    4.9  21.8    15.2       0   1695    .390     13.63   2100
  9  1200   206.0    47    2.8  23.8    15.0       0   1751    .250     13.77   2550
 10  1200   224.0    51    0.0  32.7    12.4       0   3682   5.400     10.89    670
 11   600     0.0     0   19.2   4.3    13.9       0   3636   1.660     13.06     45
 12  1200     0.0     0   23.0   4.2    15.1       0  64950    .440      6.56      4
 13  2300   235.0   103    2.6  50.5    14.3       0   2105   1.450     13.48   2400
 14  2300   216.0    95    4.6  45.9    14.4       0   1762   1.340     13.48   2200
 15  2300   192.5    84    6.4  40.6    14.5       0   1817   1.160     13.48   2050
 16  2300   176.0    77    7.5  38.4    14.9       0   1528    .490     13.77   2350
 17  2300   117.5    51   11.7  27.3    16.6       0    448    .170     12.71   2050
 18  2300    58.8    26   16.6  19.0    16.5       0    481    .180     12.71   1100
 19  2300    42.3    19   17.8  16.7    16.6       0    414    .170     12.71    688
 20  2300    18.8     8   19.8  13.6    16.6       0    297    .160     12.71    320
 21  2300     4.7     2   21.0  11.6    16.6       0    224    .160     12.71    182
 22   600     0.0     0   18.8   4.1    14.5       0   3400    .930     13.48     40
 23  2300     0.0     0   24.9   4.0    20.7       0  39026    .420      5.50      5
-------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.      HC      CO     NO2
-------------------------------------------------------------------------------------
  1   0.0    51.5      283     1.7   .070      0.0     I        R       R       R
  2   0.0    20.8      112     8.4   .060       .1   0.0    20.31   109.7     8.2
  3   0.0    30.4       82    11.7   .060       .2   0.0     7.43    20.1     2.9
  4   0.0    58.0       98    51.6   .050       .5   0.0     6.30    10.7     5.6
  5   0.0    63.8      105    71.6   .030       .4   0.0     4.99     8.2     5.6
  6   0.0    82.6      166   195.5   .060      1.5   0.0     3.23     6.5     7.6
  7   0.0   118.5      517   424.5  0.000      0.0   0.0     3.09    13.5    11.1
  8   0.0   118.0      548   485.3   .040      1.7   0.0     2.81    13.0    11.5
  9   0.0   132.9      383   642.6  0.000      0.0   0.0     2.82     8.1    13.7
 10   0.0   327.9     9715   198.1  0.000      0.0   0.0     6.41   189.8     3.9
 11   0.0    46.9      432     1.9   .070      0.0     I                R       R
 12   0.0   912.8      125      .2   .120      0.0     I        R       R       R
 13   0.0   318.6     4432  1205.8   .025      2.6   0.0     3.10    43.1    11.7
 14   0.0   244.9     3760  1014.7   .055      5.2   0.0     2.59    39.8    10.7
 15   0.0   225.8     2913   846.1   .035      3.0   0.0     2.68    34.6    10.0
 16   0.0   184.8     1197   943.7   .060      4.6   0.0     2.40    15.5    12.2
 17   0.0    42.9      329   651.9   .060      3.1   0.0      .83     6.4    12.7
 18   0.0    32.0      242   242.8  0.000      0.0   0.0     1.24     9.4     9.4
 19   0.0    24.2      201   133.6   .065      1.2   0.0     1.31    10.9     7.2
 20   0.0    14.1      154    50.6  0.000      0.0   0.0     1.72    18.7     6.1
 21   0.0     9.1      132    24.7  0.000      0.0   0.0     4.43    63.9    12.0
 22   0.0    42.6      236     1.7   .080      0.0     I        R       R       R
 23   0.0   716.0      156      .3   .060      0.0     I        R       R       R

CYCLE COMPOSITE    HC      9.368    GRAM/BHP HR
                   CO     27.867    GRAM/BHP HR
                   NO2    10.725    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .642      LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
    5-17-72 RUN 2                   ENGINE 2-3            STATIONARY DYNAMOMETER
--------------------------------------------------------------------------------
             DYNA.         MAN.  FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD   HP    VAC. LB/HR  RATIO    ALDE.     HC      CO     CO2     NO
--------------------------------------------------------------------------------
   1   600     0.0    0  18.8   4.1   14.3       39   3531  1.120   13.91     38
   2  1200     4.5    1  19.2   7.4   16.4       52    898   .130   13.18     93
   3  1200    17.9    4  18.7   8.0   16.4       56   1460   .130   13.18    180
   4  1200    40.3    9  17.5   8.8   16.3       60   1906   .130   12.94    370
   5  1200    56.0   13  16.7   9.6   16.4       78   2018   .150   12.94    575
   6  1200   112.0   26  10.4  14.8   16.7       78   1624   .150   12.82   1125
   7  1200   168.0   38   5.5  20.8   15.1       81   1808   .280   13.77   2000
   8  1200   184.0   42   4.5  21.7   15.0       68   1923   .440   13.77   2050
   9  1200   206.0   47   2.8  23.7   14.9       65   2092   .350   13.77   2450
  10  1200   224.0   51   0.0  32.7   12.2       41   4096  5.840   10.78    660
  11   600     0.0    0  19.2   3.9   13.9       46   4096  1.840   13.06     41
  12  1200     0.0    0  23.0   3.8   13.6      128  75952   .810    6.73      6
  13  2300   235.0  103   2.6  49.9   14.0       55   2386  1.800   12.94   2200
  14  2300   216.0   95   4.6  45.2   14.1       61   2158  1.730   12.94   2000
  15  2300   192.5   84   6.5  42.2   14.2       59   1927  1.480   12.94   2050
  16  2300   176.0   77   7.7  37.9   14.9       39   1577   .520   13.18   2500
  17  2300   117.5   51  12.1  26.3   16.3       57    618   .180   13.18   2300
  18  2300    58.8   26  17.1  17.6   16.4       44    516   .170   13.06    950
  19  2300    42.3   19  18.0  16.3   16.5       55    477   .170   12.94    700
  20  2300    18.8    8  19.7  13.3   16.5       39    348   .160   13.06    400
  21  2300     4.7    2  20.8  11.5   16.4       28    281   .160   13.06    220
  22   600     0.0    0  18.9   3.8   14.5       37   3744   .930   13.63     41
  23  2300     0.0    0  24.8   3.8   18.6       98  42105   .420    5.27      4
--------------------------------------------------------------------------------
           CALCULATED GRAM/HR            WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2   FAC.       HP    ALDE.      HC      CO     NO2
--------------------------------------------------------------------------------
   1   1.0    42.4      272     1.5   .070      0.0        R       R       R       R
   2   2.8    22.5       66     7.7   .060       .1      2.7   22.01    64.3     7.5
   3   3.3    39.5       71    16.2   .060       .2       .8    9.67    17.4     4.0
   4   3.9    57.1       79    36.8   .050       .5       .4    6.20     8.5     4.0
   5   5.5    66.1       99    62.5   .030       .4       .4    5.16     7.8     4.9
   6   8.6    83.0      155   190.9   .060      1.5       .3    3.24     6.1     7.5
   7  11.7   120.1      376   441.1  0.000      0.0       .3    3.13     9.8    11.5
   8  10.0   131.3      607   464.5   .040      1.7       .2    3.12    14.4    11.0
   9  10.6   156.6      529   609.0  0.000      0.0       .2    3.33    11.2    12.9
  10   7.7   356.8    10277   190.9  0.000      0.0       .2    6.97   200.8     3.7
  11   1.1    47.0      426     1.6   .070      0.0        R       R       R       R
  12   3.1   856.9      185      .2   .120      0.0        R       R       R       R
  13  18.0   360.5     5493  1103.4   .025      2.6       .2    3.50    53.4    10.7
  14  18.1   297.2     4813   914.6   .055      5.2       .2    3.14    50.9     9.7
  15  16.7   252.3     3915   891.2   .035      3.0       .2    2.99    46.4    10.6
  16  10.5   195.8     1304  1030.0   .060      4.6       .1    2.54    16.9    13.4
  17  10.8    54.8      323   677.5   .060      3.1       .2    1.07     6.3    13.2
  18   5.8    31.1      207   189.7  0.000      0.0       .2    1.21     8.0     7.4
  19   6.7    26.7      192   130.3   .065      1.2       .4    1.44    10.4     7.0
  20   3.8    15.9      148    60.6  0.000      0.0       .5    1.93    17.9     7.4
  21   2.4    11.0      127    28.7  0.000      0.0      1.1    5.35    61.7    13.9
  22    .9    42.8      215     1.6   .080      0.0        R       R       R       R
  23   3.7   726.2      146      .2   .060      0.0        R       R       R       R

CYCLE COMPOSITE     HC       9.406    GRAM/BHP HR
                    CO      33.104    GRAM/BHP HR
                    NO2     10.644    GRAM/BHP HR
                    ALDE      .259    GRAM/BHP HR
                    BSFC      .627      LB/BHP HR
```

APPENDIX G

ENGINE 2-3

COMPARISON OF 1972 TO 1973 CALIFORNIA CONFIGURATION EMISSION RATES

ENGINE 2-3

EXPERIMENTAL 23 MODE RESULTS
(Army Lab Tests)

1973 CALIFORNIA VERSION OF ENGINE

1972 RETEST OF 1972 STANDARD ENGINE

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
 5-23-72 RUN 1  1973 CALIFORNIA VERSION OF ENGINE 2-3  PER MANUF. SPECS.
--------------------------------------------------------------------------------
                DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED      LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2     NO
--------------------------------------------------------------------------------
  1    600       0.0      0   18.0    4.7   15.0        0   3390     .580    13.48     35
  2   1200       4.3      1   19.2    7.9   15.6        0    632     .130    13.77     98
  3   1200      17.2      4   18.5    8.4   15.6        0    993     .130    13.77    155
  4   1200      38.7      9   17.1   10.1   15.8        0   1184     .130    13.63    220
  5   1200      53.8     12   16.4   10.9   15.8        0   1296     .130    13.63    290
  6   1200     107.5     25   10.6   15.9   16.1        0   1348     .130    13.18    725
  7   1200     161.0     37    6.4   21.7   14.5        0   2388     .770    14.05   1100
  8   1200     177.0     40    5.0   22.7   14.5        0   2272     .640    14.05   1275
  9   1200     197.8     45    3.0   24.6   14.5        0   2214     .890    13.77   1350
 10   1200     215.0     49    0.0   32.5   12.5        0   3803    5.240    11.24    750
 11    600       0.0      0   18.2    4.7   14.1        0   3398    1.300    13.06     41
 12   1200       0.0      0   22.7    3.8   15.0        0  65277     .580     7.00      5
 13   2300     256.0    112     .1   64.8   12.1        0   3238    6.250    10.66    775
 14   2300     235.5    103    3.3   51.2   13.6        0   2400    2.520    12.94   1250
 15   2300     209.9     92    5.3   48.5   13.5        0   2348    2.780    12.94   1175
 16   2300     192.0     84    6.8   46.5   13.6        0   2345    2.600    12.94   1075
 17   2300     128.0     56   10.3   31.2   15.6        0    360     .150    13.48   1600
 18   2300      64.0     28   15.4   21.4   15.8        0    203     .150    13.48    800
 19   2300      46.0     20   17.8   18.3   15.8        0    146     .130    13.48    460
 20   2300      21.0      9   19.2   15.4   15.9        0    118     .100    13.48    270
 21   2300       5.0      2   20.5   12.7   16.2        0     76     .100    13.63    156
 22    600       0.0      0   18.0    4.7   15.2        0   2649     .580    13.18     37
 23   2300       0.0      0   24.8    3.9   31.7        0  23872     .150     3.95      4
--------------------------------------------------------------------------------
            CALCULATED GRAM/HR          WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO     NO2   FAC.        HP   ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0     49.7      172     1.7   .070       0.0      I        R        R        R
  2    0.0     16.3       68     8.5   .060        .1     0.0    16.61     69.0      8.5
  3    0.0     27.0       71    14.0   .060        .2     0.0     6.88     18.2      3.6
  4    0.0     38.4       86    24.0   .050        .4     0.0     4.40      9.8      2.7
  5    0.0     46.9       94    34.4   .030        .4     0.0     3.77      7.6      2.8
  6    0.0     72.3      141   124.1   .060       1.5     0.0     2.94      5.7      5.3
  7    0.0    155.9     1016   238.4  0.000       0.0     0.0     4.24     27.6      6.5
  8    0.0    157.0      893   292.5   .040       1.6     0.0     3.88     22.1      7.2
  9    0.0    166.0     1348   336.1  0.000       0.0     0.0     3.67     29.8      7.4
 10    0.0    333.0     9269   218.1  0.000       0.0     0.0     6.78    188.7      4.4
 11    0.0     48.8      377     2.0   .070       0.0      I        R        R        R
 12    0.0    787.1      141      .2   .120       0.0      I        R        R        R
 13    0.0    552.3    21533   438.8   .025       2.8     0.0     4.93    192.1      3.9
 14    0.0    355.2     7534   614.2   .055       5.7     0.0     3.44     73.0      6.0
 15    0.0    323.4     7735   537.3   .035       3.2     0.0     3.52     84.2      5.8
 16    0.0    313.5     7023   477.2   .060       5.0     0.0     3.73     83.5      5.7
 17    0.0     37.3      314   550.1   .060       3.4     0.0      .67      5.6      9.8
 18    0.0     14.4      215   188.7  0.000       0.0     0.0      .51      7.7      6.7
 19    0.0      8.4      160    93.0   .065       1.3     0.0      .44      7.9      4.6
 20    0.0      6.1      104    46.0  0.000       0.0     0.0      .66     11.3      5.0
 21    0.0      3.2       85    21.7  0.000       0.0     0.0     1.45     38.6      9.9
 22    0.0     34.8      176     1.8   .080       0.0      I        R        R        R
 23    0.0    651.0       83      .4   .060       0.0      I        R        R        R

CYCLE COMPOSITE   HC      8.843   GRAM/BHP HR
                  CO     70.608   GRAM/BHP HR
                  NO2     6.042   GRAM/BHP HR
                  ALDE    0.000   GRAM/BHP HR
                  BSFC     .678     LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
 5-23-72 RUN 2  1973 CALIFORNIA VERSION OF ENGINE 2-3  PER MANUF. SPECS.
--------------------------------------------------------------------------------------------
               DYNA.        MAN. FUEL     A/F                  DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR   RATIO    ALDE.    HC        CO        CO2       NO
--------------------------------------------------------------------------------------------
  1    600      0.0     0   17.5    4.7   15.8        0  4150      .210      12.94       29
  2   1200      4.3     1   19.4    7.9   16.5        0   560      .100      12.94       55
  3   1200     17.2     4   18.3    8.4   16.6        0   941      .100      12.94       85
  4   1200     38.7     9   16.8   10.1   16.6        0  1210      .100      12.94      161
  5   1200     53.8    12   15.8   10.9   16.5        0  1434      .100      12.94      270
  6   1200    107.5    25   10.3   15.9   16.4        0  1255      .100      12.94      620
  7   1200    161.0    37    6.3   21.7   14.7        0  2212      .470      14.05     1125
  8   1200    177.0    40    5.0   22.7   14.7        0  2212      .470      14.05     1313
  9   1200    197.8    45    3.0   24.6   14.5        0  2272      .770      13.91     1375
 10   1200    215.0    49    0.0   32.5   12.5        0  3897     5.240      11.48      750
 11    600      0.0     0   18.3    4.7   14.8        0  2780      .930      13.63       41
 12   1200      0.0     0   22.8    3.8   16.9        0 50087      .280       6.82        6
 13   2300    256.0   112     .1   64.8   12.2        0  4051     6.020      11.01      775
 14   2300    235.5   103    3.4   51.2   13.4        0  3217     2.970      12.94     1075
 15   2300    209.9    92    5.4   48.5   13.5        0  2978     2.780      12.94     1063
 16   2300    192.0    84    6.8   46.5   13.7        0  1716     2.360      13.18     1000
 17   2300    128.0    56   10.4   31.2   15.5        0   988      .150      13.77     1125
 18   2300     64.0    28   15.8   21.4   15.9        0   220      .150      13.63      420
 19   2300     46.0    20   17.6   18.3   15.9        0   192      .130      13.63      230
 20   2300     21.0     9   19.3   15.4   16.0        0   113      .100      13.63      115
 21   2300      5.0     2   20.4   12.7   16.4        0    76      .100      13.63       68
 22    600      0.0     0   17.5    4.7   15.5        0  2987      .280      13.48       18
 23   2300      0.0     0   24.8    3.4   29.5        0 26022      .150       4.27        3
--------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR           WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC        CO     NO2   FAC.       HP  ALDE.       HC        CO      NO2
--------------------------------------------------------------------------------------------
  1    0.0    64.5       66     1.5   .070      0.0      I        R         R        R
  2    0.0    15.4       56     5.0   .060       .1    0.0    15.70      56.6      5.1
  3    0.0    27.3       59     8.2   .060       .2    0.0     6.95      14.9      2.1
  4    0.0    41.9       70    18.5   .050       .4    0.0     4.74       7.9      2.1
  5    0.0    54.0       76    33.8   .030       .4    0.0     4.40       6.2      2.7
  6    0.0    68.8      111   112.8   .060      1.5    0.0     2.80       4.5      4.6
  7    0.0   147.5      633   249.1  0.000      0.0    0.0     4.01      17.2      6.8
  8    0.0   154.7      664   304.7   .040      1.6    0.0     3.82      16.4      7.5
  9    0.0   170.0     1164   341.7  0.000      0.0    0.0     3.76      25.8      7.6
 10    0.0   336.3     9134   214.9  0.000      0.0    0.0     6.85     185.9      4.4
 11    0.0    34.5      267     1.9   .070      0.0      I        R         R        R
 12    0.0   703.6       79      .3   .120      0.0      I        R         R        R
 13    0.0   683.0    20501   433.8   .025      2.8    0.0     6.09     182.9      3.9
 14    0.0   459.8     8588   510.9   .055      5.7    0.0     4.46      83.3      5.0
 15    0.0   408.6     7705   484.0   .035      3.2    0.0     4.45      83.8      5.3
 16    0.0   230.3     6400   445.7   .060      5.0    0.0     2.74      76.1      5.3
 17    0.0    99.7      306   377.1   .060      3.4    0.0     1.78       5.5      6.7
 18    0.0    15.4      213    98.0  0.000      0.0    0.0      .55       7.6      3.5
 19    0.0    11.5      156    46.0   .065      1.3    0.0      .57       7.9      2.3
 20    0.0     5.7      103    19.4  0.000      0.0    0.0      .62      11.1      2.1
 21    0.0     3.2       85     4.4  0.000      0.0    0.0     1.45      38.6      4.3
 22    0.0    44.8       85      .9   .080      0.0      I        R         R        R
 23    0.0   655.6       76      .2   .060      0.0      I        R         R        R

CYCLE COMPOSITE     HC       8.921    GRAM/BHP HR
                    CO      68.623    GRAM/BHP HR
                    NO2      5.088    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .678      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
 5-25-72 RUN 1  1973 CALIFORNIA VERSION OF ENGINE 2-3  PER MANUF. SPECS.
------------------------------------------------------------------------------------
           DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED  LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2     NO
------------------------------------------------------------------------------------
  1    600    0.0     0   18.3   4.7    14.9         0  4861     .770    13.33     35
  2   1200    4.3     1   19.3   7.9    15.7         0  1071     .130    13.63    130
  3   1200   17.2     4   18.5   8.4    15.7         0  1098     .130    13.48    127
  4   1200   38.7     9   17.3  10.1    15.7         0  1659     .130    13.33    255
  5   1200   53.8    12   16.2  10.9    16.2         0  1909     .130    13.18    380
  6   1200  107.5    25   10.8  15.9    16.1         0  1849     .130    12.94    840
  7   1200  161.0    37    6.4  21.7    14.6         0  2713     .640    13.48   1225
  8   1200  177.0    40    5.0  22.7    14.5         0  2798     .610    13.48   1400
  9   1200  197.8    45    3.1  24.6    14.4         0  2713     .930    13.18   1450
 10   1200  215.0    49    0.0  32.5    12.5         0  4618    5.140    10.78    825
 11    600    0.0     0   18.3   4.7    14.8         0  4053     .770    12.82     39
 12   1200    0.0     0   22.9   3.8    13.1         0 89066     .470     6.05      3
 13   2300  256.0   112     .1  64.8    12.0         0  5488    6.020    10.78    800
 14   2300  235.5   103    3.4  51.2    13.3         0  4240    3.060    12.71   1150
 15   2300  209.9    92    5.5  48.5    13.4         0  3891    2.780    12.82   1225
 16   2300  192.0    84    6.7  46.5    13.4         0  3888    2.690    12.82   1125
 17   2300  128.0    56   10.6  31.2    15.5         0  1521     .180    13.48   1800
 18   2300   64.0    28   16.0  21.4    15.7         0   832     .180    13.33    900
 19   2300   46.0    20   17.5  18.3    15.7         0   642     .180    13.48    600
 20   2300   21.0     9   19.5  15.4    15.7         0   405     .130    13.48    300
 21   2300    5.0     2   20.5  12.7    15.8         0   135     .130    13.33    179
 22    600    0.0     0   18.3   4.7    14.6         0  3389     .850    13.18     39
 23   2300    0.0     0   24.8   3.9    25.3         0 37482     .180     4.27      5
------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WI.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP   ALDE.      HC      CO      NO2
------------------------------------------------------------------------------------
  1    0.0    70.3     225     1.7   .070     0.0      I        R       R        R
  2    0.0    27.8      68    11.2   .060      .1    0.0    28.35    69.5     11.4
  3    0.0    30.5      73    11.8   .060      .2    0.0     7.76    18.6      3.0
  4    0.0    55.5      88    28.3   .050      .4    0.0     6.28     9.9      3.2
  5    0.0    70.2      97    46.4   .030      .4    0.0     5.71     7.9      3.8
  6    0.0   100.6     143   151.7   .060     1.5    0.0     4.10     5.8      6.2
  7    0.0   185.4     883   277.8 0.000      0.0    0.0     5.04    24.0      7.6
  8    0.0   200.7     884   333.4   .040     1.6    0.0     4.96    21.9      8.2
  9    0.0   210.5    1458   373.5 0.000      0.0    0.0     4.66    32.3      8.3
 10    0.0   416.2    9358   246.9 0.000      0.0    0.0     8.47   190.5      5.0
 11    0.0    61.1     234     2.0   .070     0.0      I        R       R        R
 12    0.0   982.1     105      .1   .120     0.0      I        R       R        R
 13    0.0   929.8   20603   450.0   .025     2.8    0.0     8.29   183.8      4.0
 14    0.0   608.3    8869   547.8   .055     5.7    0.0     5.90    86.0      5.3
 15    0.0   534.6    7719   559.0   .035     3.2    0.0     5.82    84.0      6.1
 16    0.0   515.8    7209   495.5   .060     5.0    0.0     6.13    85.7      5.9
 17    0.0   155.6     373   612.3   .060     3.4    0.0     2.78     6.6     10.9
 18    0.0    59.4     259   213.1 0.000      0.0    0.0     2.12     9.3      7.6
 19    0.0    38.8     220   120.5   .065     1.3    0.0     1.93    10.9      6.0
 20    0.0    20.7     134    50.9 0.000      0.0    0.0     2.25    14.6      5.5
 21    0.0     5.8     112    25.3 0.000      0.0    0.0     2.63    51.2     11.6
 22    0.0    49.8     252     1.9   .080     0.0      I        R       R        R
 23    0.0   808.8      78      .4   .060     0.0      I        R       R        R

CYCLE COMPOSITE   HC     12.506    GRAM/BHP HR
                  CO     73.085    GRAM/BHP HR
                  NO2     6.334    GRAM/BHP HR
                  ALDE    0.000    GRAM/BHP HR
                  BSFC     .678      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
   5-26-72 RUN 1                     ENGINE 2-3             STATIONARY DYNAMOMETER
----------------------------------------------------------------------------------
                DYNA.         MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED      LOAD     HP   VAC. LB/HR  RATIO     ALDE.    HC       CO      CO2     NO
----------------------------------------------------------------------------------
  1    600       0.0      0   19.2   4.0   14.5         0  4258   1.010    13.63     35
  2   1200       4.7      1   19.6   7.5   15.0         0  1022    .420    14.18     90
  3   1200      19.0      4   19.3   7.9   15.0         0  1531    .280    14.18    150
  4   1200      42.0     10   18.4   9.2   15.2         0  2773    .210    14.05    510
  5   1200      59.0     13   17.0  10.0   15.2         0  2910    .150    13.91    925
  6   1200     118.0     27   10.2  15.2   15.7         0  1907    .130    13.06   1300
  7   1200     176.0     40    6.0  20.1   15.1         0  2291    .150    14.05   2075
  8   1200     193.0     44    4.5  21.8   15.1         0  2378    .280    14.05   2100
  9   1200     216.0     49    2.8  24.2   15.0         0  2439    .210    14.31   2400
 10   1200     235.0     54    0.0  31.6   12.4         0  4431   5.410    11.72    460
 11    600       0.0      0   19.5   4.3   13.7         0  4701   2.360    13.48     40
 12   1200       0.0      0   23.4   4.1   12.8         0 79887   1.230     7.37      6
 13   2300     240.0    105    2.9  50.9   14.5         0  2449   1.270    13.77   2500
 14   2300     221.0     97    4.0  47.8   14.4         0  2107   1.380    13.63   2200
 15   2300     197.0     86    5.5  43.4   14.6         0  1734   1.200    13.63   2100
 16   2300     180.0     79    7.4  39.5   14.7         0  1764    .850    14.05   2200
 17   2300     120.0     53   11.3  27.4   16.5         0   438    .180    13.18   2300
 18   2300      60.0     26   16.6  19.2   16.5         0   472    .180    13.18   1500
 19   2300      43.0     19   18.2  16.5   16.4         0   360    .180    13.33    875
 20   2300      19.0      8   20.0  14.3   16.3         0   282    .150    13.48    425
 21   2300       4.8      2   21.2  12.1   16.1         0   192    .150    13.63    250
 22    600       0.0      0   19.2   4.3   14.1         0  3593   1.590    13.63     44
 23   2300       0.0      0   25.1   4.2   11.4         0 36038    .350     6.13      8
----------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2  FAC.       HP  ALDE.     HC       CO      NO2
----------------------------------------------------------------------------------
  1    0.0    51.3     246      1.4  .070      0.0     I       R        R        R
  2    0.0    23.6     196      6.9  .060       .1   0.0   22.01    182.8      6.4
  3    0.0    37.5     134     12.2  .060       .3   0.0    8.65     31.9      2.8
  4    0.0    79.6     122     48.6  .050       .5   0.0    8.30     12.7      5.1
  5    0.0    92.0      96     97.1  .030       .4   0.0    6.82      7.1      7.2
  6    0.0    98.3     135    222.4  .060      1.6   0.0    3.65      5.0      8.2
  7    0.0   144.8     191    435.3 0.000      0.0   0.0    3.60      4.8     10.8
  8    0.0   161.4     384    473.3  .040      1.8   0.0    3.66      8.7     10.7
  9    0.0   181.3     315    592.4 0.000      0.0   0.0    3.67      6.4     12.0
 10    0.0   361.4    8914    124.6 0.000      0.0   0.0    6.73    166.0      2.3
 11    0.0    56.2     570      1.6  .070      0.0     I       R        R        R
 12    0.0   895.6     279       .2  .120      0.0     I       R        R        R
 13    0.0   369.4    3875   1253.7  .025      2.6   0.0    3.52     36.9     11.9
 14    0.0   300.1    3971   1040.5  .055      5.3   0.0    3.10     41.0     10.8
 15    0.0   227.5    3181    914.8  .035      3.0   0.0    2.64     36.9     10.6
 16    0.0   213.6    2041    868.0  .060      4.7   0.0    2.66     25.9     11.0
 17    0.0    41.4     343    721.0  .060      3.2   0.0     .79      6.5     13.7
 18    0.0    30.7     236    323.5 0.000      0.0   0.0    1.17      9.0     12.3
 19    0.0    19.9     201    160.5  .065      1.2   0.0    1.06     10.7      8.5
 20    0.0    13.4     144     67.0 0.000      0.0   0.0    1.61     17.3      8.1
 21    0.0     7.6     121     33.0 0.000      0.0   0.0    3.63     57.3     15.7
 22    0.0    45.0     402      1.8  .080      0.0     I       R        R        R
 23    0.0   680.9     134       .5  .060      0.0     I       R        R        R

CYCLE COMPOSITE    HC      9.417    GRAM/BHP HR
                   CO     31.051    GRAM/BHP HR
                   NO2    10.765    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .635      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
  5-30-72 RUN 1                      ENGINE 2-3          STATIONARY DYNAMOMETER
-----------------------------------------------------------------------------------
             DYNA.          MAN. FUEL     A/F                  DRY CONCENTRATION
MODE SPEED   LOAD     HP   VAC. LB/HR   RATIO    ALDE.      HC       CO       CO2     NO
-----------------------------------------------------------------------------------
  1   600      0.0     0   18.5    4.7    14.7        0   3400     .930    13.48     39
  2  1200      4.3     1   19.5    7.9    15.5        0    480     .210    13.77     84
  3  1200     17.2     4   19.0    8.4    15.6        0    845     .180    13.48    147
  4  1200     38.7     9   18.0   10.1    15.8        0   1745     .150    13.48    500
  5  1200     53.8    12   16.4   10.9    16.1        0   1825     .150    13.18    813
  6  1200    107.5    25   10.3   15.9    16.9        0   1284     .150    12.47    950
  7  1200    161.0    37    5.5   21.7    15.4        0   1694     .180    13.77   2212
  8  1200    177.0    40    3.6   22.7    15.4        0   1720     .210    13.63   2250
  9  1200    197.8    45    2.5   24.6    15.2        0   1862     .280    13.63   2450
 10  1200    215.0    49    0.0   32.5    12.4        0   3693    5.780    10.89    435
 11   600      0.0     0   19.2    4.7    13.9        0   3823    2.210    13.06     43
 12  1200      0.0     0   23.3    3.8     9.4        0  60880    1.010     7.37      6
 13  2300    256.0   112    2.9   64.8    14.4        0   2221    1.380    13.63   2650
 14  2300    235.5   103    4.4   51.2    14.6        0   1908    1.300    13.77   2400
 15  2300    209.9    92    6.0   48.5    14.7        0   1564    1.230    13.63   2200
 16  2300    192.0    84    7.5   46.5    15.0        0   1589     .520    14.05   2650
 17  2300    128.0    56   11.2   31.2    16.7        0    402     .180    13.18   2350
 18  2300     64.0    28   16.7   21.4    16.4        0    473     .180    13.48   1500
 19  2300     46.0    20   18.2   18.3    16.4        0    366     .180    13.48    925
 20  2300     21.0     9   19.9   15.4    16.2        0    339     .150    13.77    525
 21  2300      5.0     2   21.2   12.7    16.1        0    201     .130    13.91    250
 22   600      0.0     0   18.7    4.7    14.5        0   3027    1.450    13.91     42
 23  2300      0.0     0   25.0    3.9    21.5        0  31268     .350     6.13      7
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.      HC       CO      NO2
-----------------------------------------------------------------------------------
  1   0.0    46.6      269     1.9   .070      0.0      I        R        R        R
  2   0.0    12.3      109     7.1   .060       .1    0.0    12.56    111.0      7.3
  3   0.0    23.4      101    13.6   .060       .2    0.0     5.96     25.6      3.5
  4   0.0    57.6      100    54.8   .050       .4    0.0     6.52     11.3      6.2
  5   0.0    67.1      111    99.2   .030       .4    0.0     5.46      9.1      8.1
  6   0.0    72.7      171   178.4   .060      1.5    0.0     2.96      7.0      7.3
  7   0.0   117.9      253   511.5  0.000      0.0    0.0     3.21      6.9     13.9
  8   0.0   126.6      312   549.5   .040      1.6    0.0     3.13      7.7     13.6
  9   0.0   147.4      448   643.9  0.000      0.0    0.0     3.26      9.9     14.2
 10   0.0   320.0    10117   125.1  0.000      0.0    0.0     6.51    205.9      2.5
 11   0.0    51.5      602     1.9   .070      0.0      I        R        R        R
 12   0.0   715.8      240      .2   .120      0.0      I        R        R        R
 13   0.0   428.5     5379  1697.7   .025      2.8    0.0     3.82     48.0     15.1
 14   0.0   290.6     3998  1213.2   .055      5.7    0.0     2.82     38.8     11.8
 15   0.0   228.9     3636  1069.0   .035      3.2    0.0     2.49     39.6     11.6
 16   0.0   227.5     1504  1259.9   .060      5.0    0.0     2.71     17.9     15.0
 17   0.0    42.4      384   824.0   .060      3.4    0.0      .76      6.9     14.7
 18   0.0    33.5      257   352.3  0.000      0.0    0.0     1.19      9.2     12.6
 19   0.0    22.2      220   186.1   .065      1.3    0.0     1.10     10.9      9.2
 20   0.0    16.9      151    87.1  0.000      0.0    0.0     1.84     16.5      9.5
 21   0.0     8.2      107    33.9  0.000      0.0    0.0     3.75     49.0     15.5
 22   0.0    40.8      394     1.9   .080      0.0      I        R        R        R
 23   0.0   575.8      130      .4   .060      0.0      I        R        R        R

CYCLE COMPOSITE    HC      7.791    GRAM/BHP HR
                   CO     30.540    GRAM/BHP HR
                   NO2    12.646    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .678      LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
   5-30-72 RUN 2                         ENGINE 2-3            STATIONARY DYNAMOMETER
-------------------------------------------------------------------------------------
                  DYNA.         MAN. FUEL     A/F                 DRY CONCENTRATION
MODE SPEED        LOAD    HP   VAC. LB/HR   RATIO     ALDE.     HC      CO        CO2      NO
-------------------------------------------------------------------------------------
  1    600         0.0     0   18.5    4.7    14.4          0   4229   1.410    14.05     39
  2   1200         4.3     1   19.6    7.9    14.7          0   1193    .580    14.18     98
  3   1200        17.2     4   19.0    8.4    15.0          0   1418    .310    14.18    170
  4   1200        38.7     9   18.0   10.1    15.2          0   2263    .180    14.05    580
  5   1200        53.8    12   16.5   10.9    16.0          0   1909    .130    13.18    775
  6   1200       107.5    25   10.2   15.9    16.9          0   1314    .100    12.71    988
  7   1200       161.0    37    5.6   21.7    15.3          0   1893    .130    13.91   2175
  8   1200       177.0    40    4.0   22.7    15.3          0   1921    .150    13.91   2100
  9   1200       197.0    45    2.7   24.6    15.1          0   2037    .180    14.05   2500
 10   1200       215.0    49    0.0   32.5    12.6          0   4066   5.960    13.33    625
 11    600         0.0     0   19.2    4.7    13.8          0   4058   2.400    13.06     43
 12   1200         0.0     0   23.3    3.8    14.1          0  65380   1.160     7.56      6
 13   2300       256.0   112    2.9   64.8    14.2          0   2477   1.660    13.33   2400
 14   2300       235.5   103    4.0   51.2    14.3          0   2048   1.550    13.33   2200
 15   2300       209.9    92    5.9   48.5    14.4          0   1821   1.450    13.48   2000
 16   2300       192.0    84    7.5   46.5    14.6          0   1819   1.050    13.77   2200
 17   2300       128.0    56   11.5   31.2    16.5          0    398    .180    12.94   2100
 18   2300        64.0    28   16.7   21.4    16.4          0    421    .180    12.94   1225
 19   2300        46.0    20   18.0   18.3    16.4          0    392    .150    12.94    750
 20   2300        21.0     9   20.0   15.4    16.2          0    309    .150    13.33    370
 21   2300         5.0     2   21.3   12.7    16.1          0    186    .130    13.33    195
 22    600         0.0     0   18.7    4.7    14.3          0   4151   1.520    13.33     34
 23   2300         0.0     0   25.0    3.9    21.6          0  34334    .350     5.75      6
-------------------------------------------------------------------------------------
             CALCULATED GRAM/HR          WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2    FAC.        HP  ALDE.       HC        CO      NO2
-------------------------------------------------------------------------------------
  1    0.0    56.2     378      1.7   .070       0.0       I        R         R        R
  2    0.0    28.9     284      7.9   .060        .1     0.0    29.44     289.0      8.0
  3    0.0    36.9     163     14.7   .060        .2     0.0     9.39      41.5      3.7
  4    0.0    71.4     115     60.7   .050        .4     0.0     8.07      13.0      6.9
  5    0.0    70.2      97     94.7   .030        .4     0.0     5.71       7.9      7.7
  6    0.0    73.2     113    182.8   .060       1.5     0.0     2.98       4.6      7.4
  7    0.0   130.8     181    498.9  0.000       0.0     0.0     3.55       4.9     13.6
  8    0.0   138.9     219    504.3   .040       1.6     0.0     3.44       5.4     12.5
  9    0.0   157.5     281    641.7  0.000       0.0     0.0     3.50       6.2     14.3
 10    0.0   304.8    9025    155.5  0.000       0.0     0.0     6.20     183.7      3.2
 11    0.0    53.4     645      1.9   .070       0.0       I        R         R        R
 12    0.0   728.4     261       .2   .120       0.0       I        R         R        R
 13    0.0   477.7    6468   1537.0   .025       2.8     0.0     4.26   57.[illegible]     13.7
 14    0.0   315.4    4823   1125.1   .055       5.7     0.0     3.06      46.5     10.9
 15    0.0   264.8    4260    965.6   .035       3.2     0.0     2.88      46.3     10.5
 16    0.0   255.8    2982   1026.9   .060       5.0     0.0     3.04      35.5     12.2
 17    0.0    42.8     391    749.8   .060       3.4     0.0      .76       7.0     13.9
 18    0.0    31.0     268    299.6  0.000       0.0     0.0     1.11       9.6     10.7
 19    0.0    24.8     192    157.4   .065       1.3     0.0     1.23       9.5      7.8
 20    0.0    16.0     156     63.4  0.000       0.0     0.0     1.74      17.0      6.9
 21    0.0     7.4     112     27.6  0.000       0.0     0.0     3.61      51.2     12.6
 22    0.0    57.4     424      1.6   .080       0.0       I        R         R        R
 23    0.0   637.1     131       .4   .060       0.0       I        R         R        R

CYCLE COMPOSITE     HC      8.422    GRAM/BHP HR
                    CO     38.529    GRAM/BHP HR
                    NO2    11.315    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .678      LB/BHP HR
```

ENGINE 2-3

9 MODE FTP

1973 CALIFORNIA VERSION OF ENGINE RESULTS

CONCENTRATION RESULTS

CALIFORNIA ARB MASS RESULTS

```
5-31-72   73 VERSION ENGINE 2-4  RUN-1  ARMY LAB                              K = .484     HUM =  72  GR/LB
--------------------------------------------------------------------------------------------------------------------
FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING        W E I G H T E D
MODE             HC     CO     CO2     NO      FACTOR     HC     CO    NO     FACTOR        HC      CO       NO
--------------------------------------------------------------------------------------------------------------------
CYCLE 1
        1 IDLE          228   .530  13.530     77     1.033      235   .547    80     .036          8.476   .020     2.863
        2 16'HG          39   .160  13.330    542     1.078       42   .172   584     .089          3.741   .015    51.996
        3 10'HG          28   .160  13.480   1218     1.067       30   .171  1300     .257          7.678   .044   333.981
        4 16'HG          17   .190  13.480    643     1.067       18   .203   686     .089          1.614   .018    61.044
        5 19'HG          17   .120  13.500    265     1.068       18   .128   283     .047           .853   .006    13.300
        6 16'HG          22   .160  13.460    612     1.069       24   .171   654     .089          2.043   .015    58.228
        7  3'HG          47  2.280  13.250   1546     1.000       47  2.281  1547     .283         27.461   .645   437.676
        8 16'HG          30   .150  12.940    837     1.111       33   .167   930     .089          2.967   .015    82.786
        9 C.T.          455   .440   7.410     85     1.674     1599   .737   142     .021         33.574   .015     2.988
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    88.458   .794  1044.862
CYCLE 2
        1 IDLE          228   .530  13.530     77     1.033      235   .547    80     .036          8.476   .020     2.863
        2 16'HG          35   .180  13.180    582     1.090       38   .196   634     .089          3.394   .017    56.438
        3 10'HG          30   .150  13.180   1140     1.091       33   .164  1244     .257          8.414   .042   319.717
        4 16'HG          30   .150  13.020    505     1.105       33   .166   558     .089          2.949   .015    49.644
        5 19'HG          16   .130  13.450    242     1.072       17   .139   259     .047           .806   .007    12.187
        6 16'HG          17   .130  12.820    410     1.124       19   .146   461     .089          1.700   .013    41.005
        7  3'HG         107  2.140  13.450   1488      .989      106  2.166  1472     .283         29.949   .613   416.492
        8 16'HG          35   .160  13.140    612     1.044       38   .175   669     .089          3.407   .016    59.571
        9 C.T.          908   .450   6.410     59     1.787     1622   .804   105     .021         34.068   .017     2.214
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    93.164   .759   960.132
CYCLE 3
        1 IDLE           75   .580  13.480     77     1.047       79   .607    81     .036          2.827   .022     2.902
        2 16'HG          53   .200  13.400    552     1.070       57   .214   590     .089          5.045   .019    52.544
        3 10'HG          35   .150  12.480    628     1.151       40   .173   723     .257         10.357   .044   185.840
        4 16'HG          35   .150  12.820    439     1.121       39   .168   492     .089          3.492   .015    43.806
        5 19'HG          35   .130  13.200    251     1.090       38   .142   274     .047          1.793   .007    12.859
        6 16'HG          30   .130  12.940    468     1.112       33   .145   521     .089          2.970   .013    46.325
        7  3'HG         106  2.060  13.300   1605     1.004      106  2.068  1611     .283         30.113   .585   455.961
        8 16'HG          35   .200  13.480    752     1.065       37   .213   801     .089          3.317   .019    71.264
        9 C.T.          867   .440   7.850     68     1.610     1396   .708   109     .021         29.313   .015     2.299
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    89.227   .739   873.799
CYCLE 4
        1 IDLE           75   .580  13.480     77     1.047       79   .607    81     .036          2.827   .022     2.902
        2 16'HG          26   .210  13.180    613     1.089       28   .229   668     .089          2.520   .020    59.421
        3 10'HG          21   .180  12.960   1069     1.109       23   .200  1186     .257          5.986   .051   304.729
        4 16'HG          16   .140  12.710    425     1.133       18   .159   482     .089          1.613   .014    42.858
        5 19'HG          13   .130  13.140    224     1.097       14   .143   246     .047           .670   .007    11.548
        6 16'HG          17   .130  12.940    522     1.113       19   .145   581     .089          1.685   .013    51.726
        7  3'HG          89  2.080  13.180   1501     1.013       90  2.107  1520     .283         25.511   .596   430.239
        8 16'HG          26   .150  13.330    678     1.079       28   .162   732     .089          2.498   .014    65.135
        9 C.T.          826   .430   7.230     67     1.640     1356   .705   110     .021         28.523   .015     2.308
        SUM------------(CYCLE COMPOSITE)-------------------------------------------------------    71.833   .753   970.865

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------      90.811   .776  1002.497

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------      80.530   .746   922.332

        FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC     0.35*(   90.811) + 0.65*(   80.530) =     84.128  PPM
                                                    CO     0.35*(     .776) + 0.65*(     .746) =       .756  PERCENT
                                                    NO     0.35*( 1002.497) + 0.65*(  922.332) =    950.390  PPM
                                                                                  CORRECTED NO =    939.785  PPM

        DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
5-31-72   73 VERSION ENGINE 2-3  RUN=2  ARMY LAB                          K =1.004      HUM =  76  GR/LB
---------------------------------------------------------------------------------------------------------------
FEDERAL          CONCENTRATION  AS  MEASURED  DILUTION      A D J U S T E D   WEIGHTING       W E I G H T E D
MODE              HC      CO    CO2     NO     FACTOR      HC      CO    NO     FACTOR        HC       CO        NO
---------------------------------------------------------------------------------------------------------------
CYCLE 1
       1 IDLE      98   .460  13.770     90    1.028      101    .473    93      .036        3.627    .017     3.331
       2 16'HG     43   .250  13.630    592    1.051       45    .263   622      .089        4.021    .023    55.355
       3 10'HG     31   .160  12.710    612    1.131       35    .181   692      .257        9.009    .046   177.847
       4 16'HG     25   .160  12.940    405    1.111       28    .178   450      .089        2.473    .016    40.059
       5 19'HG     16   .150  13.480    228    1.068       19    .160   244      .047         .904    .008    11.447
       6 16'HG     13   .150  13.060    420    1.103       14    .165   463      .089        1.276    .015    41.220
       7  3'HG     89  2.210  13.630   1631     .974       87   2.251  1589      .283       24.542    .637   449.752
       8 16'HG     26   .210  13.630    720    1.054       27    .221   759      .089        2.438    .020    67.511
       9 C.T.     833   .460   7.430     88    1.694     1411    .779   149      .021       29.633    .016     3.131
       SUM------------(CYCLE COMPOSITE)----------------------------------------------     77.921    .798   849.652
CYCLE 2
       1 IDLE      98   .460  13.770     90    1.028      101    .473    93      .036        3.627    .017     3.331
       2 16'HG     40   .210  13.770    586    1.042       42    .219   610      .089        3.709    .019    54.334
       3 10'HG     31   .160  13.180    890    1.091       34    .175   971      .257        8.690    .045   249.490
       4 16'HG     26   .150  13.180    464    1.092       28    .164   507      .089        2.526    .015    45.079
       5 19'HG     26   .140  13.480    230    1.068       28    .150   246      .047        1.305    .007    11.544
       6 16'HG     22   .160  13.480    568    1.067       23    .171   606      .089        2.090    .015    53.962
       7  3'HG    102  2.160  13.770   1482     .969       99   2.094  1436      .283       27.978    .592   406.505
       8 16'HG     35   .220  13.670    754    1.049       37    .231   791      .089        3.269    .021    70.419
       9 C.T.     831   .430   7.780     66    1.631     1355    .701   155      .021       28.455    .015     3.253
       SUM------------(CYCLE COMPOSITE)----------------------------------------------     81.649    .746   897.917
CYCLE 3
       1 IDLE     281  1.140  13.770     90     .990      278   1.129    89      .036       10.017    .041     3.208
       2 16'HG     44   .210  13.770    567    1.041       46    .219   591      .089        4.078    .019    52.556
       3 10'HG     13   .160  12.740    552    1.130       15    .181   624      .257        3.775    .046   160.279
       4 16'HG     18   .150  13.180    405    1.092       20    .164   442      .089        1.750    .015    39.373
       5 19'HG     12   .150  13.630    251    1.057       13    .159   265      .047         .596    .007    12.470
       6 16'HG     13   .150  13.330    517    1.081       14    .162   559      .089        1.250    .014    49.720
       7  3'HG     89  1.430  13.580   1521    1.008       90   1.441  1533      .283       25.378    .408   433.700
       8 16'HG     25   .210  13.770    784    1.043       26    .219   818      .089        2.321    .019    72.777
       9 C.T.     831   .430   7.720    103    1.642     1364    .706   169      .021       28.649    .015     3.551
       SUM------------(CYCLE COMPOSITE)----------------------------------------------     77.813    .585   827.633
CYCLE 4
       1 IDLE     281  1.140  13.770     90     .990      278   1.129    89      .036       10.017    .041     3.208
       2 16'HG     80   .250  13.480    597    1.059       85    .265   632      .089        7.540    .024    56.271
       3 10'HG     26   .210  13.480   1117    1.065       28    .224  1190      .257        7.117    .057   305.772
       4 16'HG     21   .180  13.220    508    1.088       23    .196   552      .089        2.033    .017    49.170
       5 19'HG     21   .150  13.770    251    1.046       22    .157   262      .047        1.032    .007    12.335
       6 16'HG     26   .210  13.750    663    1.044       27    .219   692      .089        2.417    .020    61.629
       7  3'HG     96  2.470  13.480   1314     .978       96   2.417  1286      .283       27.134    .684   363.812
       8 16'HG     34   .250  13.770    780    1.041       35    .260   812      .089        3.149    .023    72.252
       9 C.T.     794   .430   7.650     95    1.785     1417    .768   170      .021       29.766    .016     3.561
       SUM------------(CYCLE COMPOSITE)----------------------------------------------     90.205    .889   928.011

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------     79.785    .772   873.784

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------     84.009    .737   877.822

       FOUR CYCLE COMPOSITE - REPORTED VALUES -     HC     0.35*(   79.785) + 0.65*(   84.009) =     82.531  PPM
                                                    CO     0.35*(     .772) + 0.65*(     .737) =       .749  PERCENT
                                                    NO     0.35*(  873.784) + 0.65*(  877.822) =    876.409  PPM
                                                                                 CORRECTED NO =    879.549  PPM

       DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
5-11-72   2A VERSION ENGINE 2-1  RUN-1  ARMY LAB                        K =1.063     HUM =  94  GR/LB
---------------------------------------------------------------------------------------------------------
FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION    A D J U S T E D   WEIGHTING       W E I G H T E D
MODE           HC     CO     CO2     NO     FACTOR     HC    CO     NO     FACTOR        HC      CO       NO
---------------------------------------------------------------------------------------------------------
CYCLE 1
      1 IDLE   296   .370  12.710     62    1.097     325   .406    68     .036      11.692   .015    2.449
      2 16'HG   63   .180  12.440    588    1.107      70   .199   651     .084       6.207   .018   57.933
      3 10'HG   46   .150  12.940   1357    1.110      51   .166  1506     .257      13.121   .043  387.063
      4 16'HG   35   .210  13.180    710    1.088      38   .229   773     .089       3.390   .020   68.773
      5 19'HG   26   .310  13.210    288    1.083      28   .336   312     .047       1.324   .016   14.666
      6 16'HG   34   .150  13.060    645    1.101      37   .165   710     .089       3.331   .015   63.194
      7  3'HG  116  2.600  12.740   1338    1.024     119  2.661  1370     .283      33.604   .753  387.601
      8 16'HG   36   .160  13.200    747    1.089      39   .174   813     .089       3.488   .016   72.379
      9 C.T.   965   .400   7.300     78    1.697    1638   .679   132     .021      34.399   .014    2.780
      SUM------------(CYCLE COMPOSITE)------------------------------------------  110.557   .909 1056.840
CYCLE 2
      1 IDLE   246   .370  12.710     62    1.032     325   .406    68     .036      11.692   .015    2.449
      2 16'HG   58   .150  13.480    612    1.065      62   .160   652     .089       5.496   .014   57.997
      3 10'HG   41   .140  13.630   1326    1.055      43   .148  1399     .257      11.116   .038  359.520
      4 16'HG   35   .150  13.480    671    1.067      37   .160   716     .089       3.323   .014   63.705
      5 19'HG   28   .130  13.770    298    1.046      29   .136   312     .047       1.376   .006   14.647
      6 16'HG   34   .150  13.500    653    1.065      36   .160   696     .089       3.223   .014   61.910
      7  3'HG  114  2.600  13.180   1344     .993     113  2.582  1335     .283      32.034   .731  377.666
      8 16'HG   31   .150  13.630    705    1.055      33   .158   744     .089       2.912   .014   66.223
      9 C.T.  1041   .380   7.210     79    1.607    1673   .611   127     .021      35.126   .013    2.666
      SUM------------(CYCLE COMPOSITE)------------------------------------------  106.300   .859 1006.782
CYCLE 3
      1 IDLE   165   .440  13.910     83    1.013     167   .446    84     .036       6.020   .016    3.028
      2 16'HG   36   .150  13.480    587    1.067      38   .160   626     .089       3.418   .014   55.725
      3 10'HG   34   .150  13.630   1412    1.055      36   .158  1490     .257       9.220   .041  382.908
      4 16'HG   31   .150  13.630    633    1.055      33   .158   668     .089       2.912   .014   59.460
      5 19'HG   26   .130  13.720    330    1.050      27   .136   346     .047       1.283   .006   16.281
      6 16'HG   31   .130  13.460    622    1.069      33   .139   665     .089       2.951   .012   59.202
      7  3'HG  114  2.380  13.180   1429    1.000     114  2.381  1429     .283      32.277   .674  404.316
      8 16'HG   35   .160  13.520    725    1.063      37   .170   771     .089       3.312   .015   68.604
      9 C.T.   907   .360   7.670     82    1.642    1489   .591   135     .021      31.279   .012    2.828
      SUM------------(CYCLE COMPOSITE)------------------------------------------   92.671   .805 1052.353
CYCLE 4
      1 IDLE   165   .440  13.910     83    1.013     167   .446    84     .036       6.020   .016    3.028
      2 16'HG   38   .150  13.720    597    1.044      40   .157   623     .089       3.532   .014   55.482
      3 10'HG   34   .150  13.910   1357    1.034      35   .155  1403     .257       9.036   .040  360.645
      4 16'HG   31   .150  13.910    695    1.034      32   .155   719     .089       2.854   .014   63.980
      5 19'HG   26   .130  14.050    295    1.025      27   .133   302     .047       1.253   .006   14.215
      6 16'HG   27   .130  13.800    689    1.044      28   .136   719     .089       2.508   .012   63.995
      7  3'HG  113  2.600  13.480   1362     .973     110  2.530  1325     .283      31.116   .716  375.047
      8 16'HG   35   .150  13.460    700    1.030      36   .155   721     .089       3.210   .014   64.191
      9 C.T.   910   .350   7.610     98    1.617    1471   .566   158     .021      30.899   .012    3.328
      SUM------------(CYCLE COMPOSITE)------------------------------------------   90.426   .844 1003.910

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------  108.428   .884 1031.811

      AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------   91.549   .824 1028.132

      FOUR CYCLE COMPOSITE - REPORTED VALUES -   HC   0.35*( 108.428) + 0.65*(   91.549) =    97.457  PPM
                                                 CO   0.35*(    .884) + 0.65*(     .824) =      .845  PERCENT
                                                 NO   0.35*( 1031.811) + 0.65*( 1028.132) =  1029.419  PPM
                                                                         CORRECTED NO =  1094.218  PPM

      DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.5*HC)
```

```
       5-30-72   73 VERSION ENGINE 2-3  RUN-1  ARMY LAB                       K = 1.05     HUM =  94  GR/LB
       ------------------------------------------------------------------------------------------------------------------
       MASS        CONCENTRATION AS MEASURED    TOTAL    FUEL      ADJUSTED (MASS)      WT.        WEIGHTED (MASS)
       MODE          HC     CO     CO2    NO    CARBON   CONS.     HC      CO    NO2   FACT.     HC       CO   NO2(K)  HP
       ------------------------------------------------------------------------------------------------------------------

CYCLE 1
       1 IDLE       296   .370  12.71    62   13.400    1907      45     106     3   .232     10.6      25      .7    0
       2 16 HG       63   .180  12.94   588   13.188    8127      42     224   120   .077      3.2      17     9.3   23
       3 10 HG       46   .150  12.94  1357   13.140   12530      47     289   430   .147      7.0      42    63.2   49
       4 16 HG       35   .210  13.18   710   13.428    8127      23     257   143   .077      1.8      20    11.0   23
       5 19 HG       26   .310  13.20   288   13.538    6061      13     280    43   .057       .7      16     2.4   10
       6 16 HG       34   .150  13.06   645   13.247    8127      23     186   131   .077      1.7      14    10.1   23
       7  3 HG      116  2.600  12.74  1338   15.465   19567     159    6645   562   .113     17.9     751    63.5   85
       8 16 HG       36   .160  13.20   747   13.399    8127      24     196   150   .077      1.8      15    11.6   23
       9 C.T.       965   .400   7.30    78    8.742    1907     227     176     6   .143     32.5      25      .8    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------     3.2      38     7.1

CYCLE 2
       1 IDLE       296   .370  12.71    62   13.400    1907      45     106     3   .232     10.6      25      .7    0
       2 16 HG       58   .150  13.48   612   13.693    8127      37     180   121   .077      2.9      14     9.3   23
       3 10 HG       41   .140  13.63  1326   13.814   12530      40     257   399   .147      5.9      38    58.7   48
       4 16 HG       35   .150  13.48   671   13.668    8127      22     180   132   .077      1.7      14    10.2   23
       5 19 HG       28   .130  13.77   298   13.930    6061      13     114    43   .057       .7       7     2.5   10
       6 16 HG       34   .150  13.50   653   13.687    8127      22     180   129   .077      1.7      14     9.9   23
       7  3 HG      114  2.600  13.18  1344   15.903   19567     151    6462   549   .113     17.1     730    62.0   85
       8 16 HG       31   .150  13.63   705   13.813    8127      20     178   138   .077      1.5      14    10.6   23
       9 C.T.      1041   .380   7.71    79    9.214    1907     233     159     5   .143     33.3      23      .8    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------     3.1      36     6.8

CYCLE 3
       1 IDLE       165   .440  13.91    83   14.528    1907      23     117     4   .232      5.4      27      .8    0
       2 16 HG       36   .150  13.48   587   13.669    8127      23     180   116   .077      1.8      14     8.9   23
       3 10 HG       34   .150  13.63  1412   13.817   12530      33     275   425   .147      4.9      40    62.5   48
       4 16 HG       31   .150  13.63   633   13.813    8127      20     178   124   .077      1.5      14     9.5   23
       5 19 HG       26   .130  13.72   330   13.878    6061      12     115    48   .057       .7       7     2.7   10
       6 16 HG       31   .130  13.46   622   13.623    8127      20     157   123   .077      1.5      12     9.5   23
       7  3 HG      114  2.380  13.18  1428   15.683   19567     154    5998   592   .113     17.4     678    66.8   85
       8 16 HG       35   .160  13.52   725   13.718    8127      22     191   143   .077      1.7      15    11.0   23
       9 C.T.       907   .360   7.67    82    9.010    1907     207     154     6   .143     29.6      22      .8    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------     2.7      34     7.1

CYCLE 4
       1 IDLE       165   .440  13.91    83   14.528    1907      23     117     4   .232      5.4      27      .8    0
       2 16 HG       38   .150  13.77   597   13.961    8127      24     176   115   .077      1.8      14     8.9   23
       3 10 HG       34   .150  13.91  1357   14.097   12530      33     269   400   .147      4.8      40    58.9   48
       4 16 HG       31   .150  13.91   695   14.093    8127      19     175   133   .077      1.5      13    10.2   23
       5 19 HG       26   .130  14.05   295   14.208    6061      12     112    42   .057       .7       6     2.4   10
       6 16 HG       27   .130  13.80   689   13.959    8127      17     153   133   .077      1.3      12    10.3   23
       7  3 HG      113  2.600  13.48  1362   16.202   19567     147    6343   546   .113     16.7     717    61.7   85
       8 16 HG       35   .150  13.96   700   14.148    8127      22     174   133   .077      1.7      13    10.3   23
       9 C.T.       910   .350   7.81    98    9.143    1907     205     147     7   .143     29.3      21     1.0    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------     2.6      36     6.8

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------     3.2      37     7.0

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------     2.6      35     7.0

       FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.2) + 0.65(     2.6) =    2.825  (MASS)
                                                CO  0.35(      37) + 0.65(      35) =     35.8  (MASS)
                                                NO2 0.35(     7.0) + 0.65(     7.0) =    6.979  (MASS)
                                                               CORRECTED NO2 =    7.346  (MASS)
```

```
          5-31-72   73 VERSION ENGINE 2-3  RUN-1  ARMY LAB                    K =  .99     HUM =  72  GR/LB
          ---------------------------------------------------------------------------------------------------------------
          MASS          CONCENTRATION AS MEASURED     TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
          MODE            HC     CO      CO2     NO   CARBON   CONS.      HC      CO    NO2   FACT.      HC      CO  NO2(K)  HP
          ---------------------------------------------------------------------------------------------------------------

CYCLE 1
          1 IDLE         228    .530   13.53     77   14.306    1907      33     143      3   .232      7.6      33      .8   0
          2 16 HG         39    .160   13.33    542   13.532    8127      25     194    108   .077      1.9      15     8.3  23
          3 10 HG         28    .160   13.48   1218   13.670   12530      28     296    371   .147      4.1      44    54.5  48
          4 16 HG         17    .190   13.48    643   13.688    8127      11     228    127   .077       .8      18     9.8  23
          5 19 HG         17    .120   13.50    265   13.638    6061       8     108     39   .057       .5       6     2.2  10
          6 16 HG         22    .160   13.46    612   13.644    8127      14     193    121   .077      1.1      15     9.3  23
          7  3 HG         97   2.280   13.25   1546   15.635   19567     131    5764    642   .113     14.8     651    72.6  85
          8 16 HG         30    .150   12.94    837   13.122    8127      20     188    172   .077      1.5      14    13.3  23
          9 C.T.         955    .440    7.41     85    8.881    1907     221     191      6   .143     31.7      27      .9   0
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     2.7      34     7.1

CYCLE 2
          1 IDLE         228    .530   13.53     77   14.306    1907      33     143      3   .232      7.6      33      .8   0
          2 16 HG         35    .180   13.18    582   13.398    8127      23     221    117   .077      1.8      17     9.0  23
          3 10 HG         30    .150   13.18   1140   13.362   12530      30     284    355   .147      4.5      42    52.2  48
          4 16 HG         30    .150   13.02    505   13.202    8127      20     187    103   .077      1.5      14     7.9  23
          5 19 HG         16    .130   13.45    242   13.597    6061       8     117     36   .057       .4       7     2.0  10
          6 16 HG         17    .130   12.82    410   12.968    8127      12     165     85   .077       .9      13     6.6  23
          7  3 HG        107   2.190   13.45   1488   15.756   19567     144    5494    614   .113     16.2     621    69.3  85
          8 16 HG         35    .160   13.14    612   13.338    8127      23     197    124   .077      1.8      15     9.5  23
          9 C.T.         908    .450    6.91     59    8.341    1907     224     208      4   .143     32.1      30      .6   0
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     2.8      33     6.5

CYCLE 3
          1 IDLE          75    .580   13.48     77   14.141    1907      11     158      3   .232      2.5      37      .8   0
          2 16 HG         53    .200   13.40    552   13.657    8127      34     240    109   .077      2.6      19     8.4  23
          3 10 HG         35    .150   12.48    628   12.668   12530      37     300    206   .147      5.5      44    30.3  48
          4 16 HG         35    .150   12.82    439   13.008    8127      24     189     91   .077      1.8      15     7.0  23
          5 19 HG         35    .130   13.20    251   13.368    6061      17     119     38   .057      1.0       7     2.2  10
          6 16 HG         30    .130   12.94    468   13.102    8127      20     163     96   .077      1.5      13     7.4  23
          7  3 HG        106   2.060   13.30   1605   15.474   19567     145    5262    674   .113     16.4     595    76.1  85
          8 16 HG         35    .200   13.48    752   13.718    8127      22     239    148   .077      1.7      18    11.4  23
          9 C.T.         867    .440    7.85     68    9.226    1907     194     184      5   .143     27.7      26      .7   0
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     2.5      32     6.0

CYCLE 4
          1 IDLE          75    .580   13.48     77   14.141    1907      11     158      3   .232      2.5      37      .8   0
          2 16 HG         26    .210   13.18    613   13.418    8127      17     257    123   .077      1.3      20     9.5  23
          3 10 HG         21    .180   12.96   1069   13.163   12530      22     346    338   .147      3.2      51    49.7  48
          4 16 HG         16    .140   12.71    425   12.867    8127      11     179     89   .077       .8      14     6.9  23
          5 19 HG         13    .130   13.14    224   13.284    6061       6     120     34   .057       .4       7     1.9  10
          6 16 HG         17    .130   12.94    522   13.088    8127      11     163    108   .077       .9      13     8.3  23
          7  3 HG         89   2.080   13.18   1501   15.356   19567     122    5354    635   .113     13.8     605    71.8  85
          8 16 HG         26    .150   13.33    678   13.508    8127      17     182    135   .077      1.3      14    10.4  23
          9 C.T.         828    .430    7.73     67    9.054    1907     188     183      5   .143     26.9      26      .7   0
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     2.1      33     6.6

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)--------------------------------------     2.7      33     6.8

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)--------------------------------------     2.3      32     6.3

          FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.7) + 0.65(     2.3) =    2.454  (MASS)
                                                   CO  0.35(      33) + 0.65(      32) =     32.7  (MASS)
                                                   NO2 0.35(     6.8) + 0.65(     6.3) =    6.482  (MASS)
                                                                   CORRECTED NO2 =    6.416  (MASS)
```

```
5-31-72   73 VERSION ENGINE 2-3  RUN-2  ARMY LAB                         K = 1.00     HUM =  76  GR/LB
--------------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED     TOTAL     FUEL      ADJUSTED (MASS)        WT.        WEIGHTED (MASS)
MODE            HC      CO     CO2     NO   CARBON    CONS.     HC      CO    NO2    FACT.     HC      CO   NO2(K)  HP
--------------------------------------------------------------------------------------------------------------------

CYCLE 1
  1 IDLE        98    .460   13.77     90   14.336     1907     14     124      4    .232     3.3     29      .9    0
  2 16 HG       43    .250   13.63    592   13.926     8127     27     295    115    .077     2.1     23     8.8   23
  3 10 HG       31    .160   12.71    612   12.903    12530     33     314    197    .147     4.8     46    29.0   48
  4 16 HG       25    .160   12.94    405   13.127     8127     17     200     83    .077     1.3     15     6.4   23
  5 19 HG       18    .150   13.48    228   13.649     6061      9     135     34    .057      .5      8     1.9   10
  6 16 HG       13    .150   13.06    420   13.224     8127      9     186     86    .077      .7     14     6.6   23
  7  3 HG       84   2.310   13.63   1631   16.036    19567    117    5694    661    .113    13.3    643    74.7   85
  8 16 HG       26    .210   13.63    720   13.868     8127     16     249    140    .077     1.3     19    10.8   23
  9 C.T.       833    .460    7.43     88    8.790     1907    195     202      6    .143    27.9     29      .9    0
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     2.3     34     5.8

CYCLE 2
  1 IDLE        98    .460   13.77     90   14.336     1907     14     124      4    .232     3.3     29      .9    0
  2 16 HG       40    .210   13.77    586   14.023     8127     25     246    113    .077     1.9     19     8.7   23
  3 10 HG       31    .160   13.18    890   13.373    12530     31     303    277    .147     4.6     45    40.7   48
  4 16 HG       26    .150   13.18    464   13.358     8127     17     184     94    .077     1.3     14     7.2   23
  5 19 HG       26    .140   13.48    230   13.648     6061     12     126     34    .057      .7      7     1.9   10
  6 16 HG       22    .160   13.48    568   13.664     8127     14     192    112    .077     1.1     15     8.6   23
  7  3 HG      102   2.160   13.77   1482   16.040    19567    134    5323    600    .113    15.2    601    67.8   85
  8 16 HG       35    .220   13.67    754   13.928     8127     22     259    146    .077     1.7     20    11.2   23
  9 C.T.       831    .430    7.78     95    9.107     1907    188     182      7    .143    26.9     26      .9    0
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     2.3     32     6.1

CYCLE 3
  1 IDLE       281   1.140   13.77     90   15.213     1907     38     289      4    .232     8.8     67      .9    0
  2 16 HG       44    .210   13.77    567   14.028     8127     28     246    109    .077     2.1     19     8.4   23
  3 10 HG       13    .160   12.74    552   12.914    12530     14     314    178    .147     2.0     46    26.1   48
  4 16 HG       18    .150   13.18    405   13.349     8127     12     184     82    .077      .9     14     6.3   23
  5 19 HG       12    .150   13.63    251   13.793     6061      6     133     37    .057      .3      8     2.1   10
  6 16 HG       13    .150   13.33    517   13.494     8127      8     182    103    .077      .7     14     8.0   23
  7  3 HG       89   1.430   13.58   1521   15.106    19567    125    3742    654    .113    14.1    423    73.9   85
  8 16 HG       25    .210   13.77    784   14.007     8127     16     246    151    .077     1.2     19    11.6   23
  9 C.T.       831    .430    7.72    103    9.047     1907    189     183      7    .143    27.1     26     1.0    0
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     2.4     26     5.7

CYCLE 4
  1 IDLE       281   1.140   13.77     90   15.213     1907     38     289      4    .232     8.8     67      .9    0
  2 16 HG       80    .250   13.48    597   13.816     8127     51     297    117    .077     3.9     23     9.0   23
  3 10 HG       26    .210   13.48   1117   13.718    12530     26     387    339    .147     3.8     57    49.8   48
  4 16 HG       21    .180   13.22    508   13.423     8127     14     220    102    .077     1.1     17     7.9   23
  5 19 HG       21    .150   13.77    251   13.943     6061     10     132     36    .057      .6      8     2.1   10
  6 16 HG       26    .210   13.75    663   13.988     8127     16     246    128    .077     1.3     19     9.8   23
  7  3 HG       98   2.470   13.48   1314   16.056    19567    129    6081    532    .113    14.6    687    60.1   85
  8 16 HG       34    .250   13.77    780   14.057     8127     21     292    150    .077     1.6     22    11.5   23
  9 C.T.       794    .430    7.05     95    8.338     1907    196     199      7    .143    28.0     28     1.0    0
  SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------     2.6     38     6.3

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------------     2.3     33     6.0

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------------     2.5     32     6.0

  FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.3) + 0.65(     2.5) =    2.435  (MASS)
                                          CO  0.35(      33) + 0.65(      32) =     32.7  (MASS)
                                          NO2 0.35(     6.0) + 0.65(     6.0) =    5.995  (MASS)
                                                           CORRECTED NO2 =    6.012  (MASS)
```

ENGINE 2-3

EXPERIMENTAL 23 MODE RESULTS

1972 STANDARD ENGINE

1973 CALIFORNIA VERSION OF ENGINE

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
 6-15-72 RUN 1       1972 VERSION OF ENGINE  2-3         PER MANUF. SPECS.
--------------------------------------------------------------------------------
              DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED    LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC        CO      CO2      NO
--------------------------------------------------------------------------------
  1    600     0.0      0  18.2    4.2    15.2        0   2093     .740    13.48      50
  2   1200     4.6      1  19.8    6.5    15.7        0    914     .100    13.77      54
  3   1200    18.4      4  19.0    7.5    15.5        0    424     .180    14.05     126
  4   1200    41.4      9  17.4    8.5    15.7        0   1095     .130    13.77     345
  5   1200    57.5     13  16.5   10.2    15.9        0   1441     .130    13.48     765
  6   1200   115.0     25   9.2   15.5    17.2        0    812     .130    12.82     888
  7   1200   172.5     39   5.2   21.0    15.5        0   1333     .150    13.91    2188
  8   1200   188.6     43   3.4   22.5    15.5        0   1380     .280    13.91    2138
  9   1200   211.6     48   1.1   24.2    15.2        0   1474     .390    14.05    2400
 10   1200   230.0     53   0.0   32.2    12.6        0   2858    5.610    11.13     950
 11    600     0.0      0  18.5    4.0    14.6        0   2275    1.520    13.33      53
 12   1200     0.0      0  22.2    3.7    16.0        0  51707     .700     7.65      11
 13   2300   260.0    114   0.0   64.5    12.1        0   3118    6.500    10.25    1000
 14   2300   239.2    105   3.0   51.0    13.5        0   2435    2.970    12.82    1500
 15   2300   219.2     93   4.4   44.5    14.5        0   1865    1.380    13.48    2400
 16   2300   145.0     85   5.8   42.0    14.6        0   1726    1.300    13.33    2200
 17   2300   130.0     57   9.4   31.2    16.8        0    554     .150    12.71    1700
 18   2300    65.0     28  15.7   19.8    16.8        0    532     .150    12.82    1363
 19   2300    46.8     20  17.2   17.0    16.8        0    418     .150    12.82     766
 20   2300    20.8      9  19.6   13.0    16.4        0    228     .150    13.18     285
 21   2300     5.2      2  21.0   10.7    16.3        0    197     .130    13.33     165
 22    600     0.0      0  18.0    3.6    15.1        0   1834     .670    13.63      47
 23   2300     0.0      0  24.0    4.0    17.8        0  30068     .350     8.68       8
--------------------------------------------------------------------------------
           CALCULATED GRAM/HR           WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.       HP  ALDE.       HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0    27.6      197      2.2   .070      0.0      I        R        R        R
  2    0.0    19.3       43      3.8   .060       .1    0.0    18.36     40.6      3.6
  3    0.0    10.1       87     10.0   .060       .3    0.0     2.41     20.6      2.4
  4    0.0    30.1       72     31.5   .050       .5    0.0     3.19      7.6      3.3
  5    0.0    48.5       88     85.4   .030      1.1    0.0     1.35      2.5      2.4
  6    0.0    43.8      142    159.1   .060      1.6    0.0     1.67      5.4      6.1
  7    0.0    89.5      203    487.5  0.000      0.0    0.0     2.27      5.2     12.4
  8    0.0    98.3      403    505.6   .040      1.7    0.0     2.28      9.3     11.7
  9    0.0   110.4      593    549.6  0.000      0.0    0.0     2.29     12.3     12.4
 10    0.0   245.2     9722    270.6  0.000      0.0    0.0     4.67    185.0      5.1
 11    0.0    27.4      369      2.1   .070      0.0      I        R        R        R
 12    0.0   641.8      176       .5   .120      0.0      I        R        R        R
 13    0.0   534.7    22515    569.3   .025      2.8    0.0     4.70    197.7      5.0
 14    0.0   351.4     8656    718.5   .055      5.8    0.0     3.35     82.6      6.9
 15    0.0   250.3     3740   1068.9   .035      3.3    0.0     2.68     40.1     11.4
 16    0.0   222.1     3380    940.0   .060      5.1    0.0     2.60     39.6     11.0
 17    0.0    60.7      332    618.5   .060      3.4    0.0     1.07      5.8     10.9
 18    0.0    36.7      209    312.1  0.000      0.0    0.0     1.29      7.3     11.0
 19    0.0    24.8      180    150.7   .065      1.3    0.0     1.21      8.8      7.4
 20    0.0    10.1      134     41.8  0.000      0.0    0.0     1.11     14.7      4.6
 21    0.0     7.1       95     19.7  0.000      0.0    0.0     3.11     41.5      8.7
 22    0.0    20.7      153      1.8   .080      0.0      I        R        R        R
 23    0.0   453.2      107       .4   .060      0.0      I        R        R        R

CYCLE COMPOSITE      HC        6.726    GRAM/BHP HR
                     CO       56.555    GRAM/BHP HR
                     NO2       8.535    GRAM/BHP HR
                     ALDE      0.000    GRAM/BHP HR
                     BSFC       .610      LB/BHP HR
```

```
                            PROJECT 11-2877-01  CONTROL TECHNOLOGY
6-16-72 RUN 1                 1972 VERSION OF ENGINE  2-3         PER MANUF. SPECS.
------------------------------------------------------------------------------------------
             DYNA.          MAN. FUEL    A/F                    DRY CONCENTRATION
MODE SPEED   LOAD     HP   VAC. LB/HR   RATIO   ALDE.     HC       CO       CO2       NO
------------------------------------------------------------------------------------------
  1   600     0.0      0   18.1   4.0    15.5      0    2166     .580     12.94      43
  2  1200     4.6      1   19.6   7.3    16.0      0     355     .130     13.63      63
  3  1200    18.4      4   18.5   7.6    16.2      0     618     .130     13.33     140
  4  1200    41.4      9   17.3   8.7    16.3      0    1146     .130     13.18     365
  5  1200    57.5     13   16.0   9.9    16.5      0    1300     .130     12.94     570
  6  1200   115.0     26    9.0  16.3    16.7      0     773     .130     12.94     875
  7  1200   172.5     39    4.7  20.7    15.5      0    1130     .130     13.91    1925
  8  1200   188.6     43    3.0  22.7    15.5      0    1289     .180     13.91    2050
  9  1200   211.6     48    1.5  24.6    15.2      0    1484     .470     13.91    2150
 10  1200   230.0     53    0.0  32.0    12.6      0    2711    5.500     11.13     900
 11   600     0.0      0   18.7   3.6    14.1      0    2402    2.500     13.06      48
 12  1200     0.0      0   22.4   4.0    15.9      0   50691     .930      7.56       9
 13  2300   260.0    114    0.0  65.0    14.7      0    3410    6.440     10.43     938
 14  2300   239.2    105    2.6  50.2    13.6      0    2406    2.690     13.06    1550
 15  2300   213.2     93    4.3  45.0    14.5      0    1662    1.300     13.63    2387
 16  2300   195.0     85    5.2  42.6    14.6      0    1547    1.270     13.63    2225
 17  2300   130.0     57    9.2  31.5    16.7      0     437     .130     12.94    1625
 18  2300    65.0     28   15.4  19.9    16.7      0     538     .150     12.82    1300
 19  2300    46.8     20   17.0  17.2    16.6      0     409     .130     12.82     700
 20  2300    20.8      9   19.1  13.3    16.5      0     242     .100     13.33     305
 21  2300     5.2      2   20.5  11.5    16.4      0     188     .100     13.18     155
 22   600     0.0      0   18.4   3.7    15.2      0    1726     .770     13.48      51
 23  2300     0.0      0   24.1   3.9    17.7      0   40794     .390      7.56      11
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR              WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2     FAC.      HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1    0.0    28.6     155      1.9    .070      0.0      I        R        R        R
  2    0.0     8.5      63      5.0    .060       .1    0.0      8.1.     60.0      4.8
  3    0.0    15.8      67     11.8    .060       .3    0.0      3.75     15.9      2.8
  4    0.0    33.7      77     35.6    .050       .5    0.0      3.56      8.2      3.8
  5    0.0    44.2      84     64.4    .030       .4    0.0      3.37      6.8      4.9
  6    0.0    43.5     148    163.4    .060      1.6    0.0      1.66      5.6      6.2
  7    0.0    75.0     174    424.0   0.000      0.0    0.0      1.90      4.4     10.8
  8    0.0    93.3     263    492.9    .040      1.7    0.0      2.17      6.1     11.4
  9    0.0   114.0     729    548.2   0.000      0.0    0.0      2.36     15.1     11.3
 10    0.0   232.9    9542    256.6   0.000      0.0    0.0      4.43    181.6      4.9
 11    0.0    24.8     522      1.6    .070      0.0      I        R        R        R
 12    0.0   678.3     251       .4    .120      0.0      I        R        R        R
 13    0.0   584.2   22285    533.2    .025      2.8    0.0      5.13    195.7      4.7
 14    0.0   342.6    7738    732.8    .055      5.8    0.0      3.27     73.9      7.0
 15    0.0   224.7    3551   1071.8    .035      3.3    0.0      2.41     38.0     11.5
 16    0.0   198.6    3293    948.2    .060      5.1    0.0      2.33     38.6     11.1
 17    0.0    47.6     286    587.8    .060      3.4    0.0       .84      5.0     10.3
 18    0.0    37.3     210    299.1   0.000      0.0    0.0      1.31      7.4     10.5
 19    0.0    24.5     158    139.6    .065      1.3    0.0      1.20      7.7      6.8
 20    0.0    10.8      91     45.4   0.000      0.0    0.0      1.19      9.9      5.0
 21    0.0     7.4      79     20.2   0.000      0.0    0.0      3.24     34.8      8.9
 22    0.0    20.1     181      2.0    .080      0.0      I        R        R        R
 23    0.0   599.9     116       .5    .060      0.0      I        R        R        R

CYCLE COMPOSITE      HC       7.291    GRAM/BHP HR
                     CO      55.839    GRAM/BHP HR
                     NO2      8.658    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .632      LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-13-72 RUN 1  1973 CALIFORNIA VERSION OF ENGINE 2-3  PER MANUF. SPECS.
--------------------------------------------------------------------------------------
                 DYNA.         MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED       LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
--------------------------------------------------------------------------------------
   1   600        0.0     0   17.5    4.7   15.9        0   3503     .550    12.71      35
   2  1200        4.0     1   19.2    7.9   16.2        0    292     .130    13.33      64
   3  1200       17.0     4   18.5    8.4   16.4        0    269     .130    12.94      88
   4  1200       39.0     9   16.4   10.1   16.6        0     67     .130    12.94     182
   5  1200       54.0    12   15.0   10.9   16.4        0    953     .130    12.94     340
   6  1200      108.0    25    9.5   15.9   16.2        0    919     .150    12.94     810
   7  1200      161.0    37    5.5   21.7   14.9        0   1063     .670    13.48    1375
   8  1200      177.0    40    3.5   22.7   14.9        0    974     .740    13.63    1500
   9  1200      198.0    45    2.7   24.6   14.8        0    995     .670    13.48    1700
  10  1200      222.0    51    0.0   32.5   12.3        0   3004    5.780    11.01     750
  11   600        0.0     0   18.5    4.7   15.3        0   2165     .850    12.94      44
  12  1200        0.0     0   22.0    3.8   17.2        0  52436     .470     6.64       8
  13  2300      250.0   109    0.0   64.8   12.2        0   2978    6.020    10.66     865
  14  2300      236.0   103    3.0   51.2   12.8        0   2508    4.540    11.72     825
  15  2300      210.0    92    4.9   48.5   13.6        0   2194    2.480    12.94    1400
  16  2300      192.0    84    6.0   46.5   13.7        0   2282    2.280    12.94    1512
  17  2300      128.0    56   10.0   31.2   15.9        0    528     .180    13.18    1575
  18  2300       64.0    28   15.3   21.4   15.8        0    489     .210    13.33     825
  19  2300       46.0    20   15.6   18.3   16.2        0    230     .150    13.18     360
  20  2300       21.0     9   18.7   15.4   16.1        0    157     .130    13.33     215
  21  2300        5.0     2   20.5   12.7   16.1        0    135     .130    13.18     150
  22   600        0.0     0   18.0    4.7   15.6        0   2478     .610    13.06      44
  23  2300        0.0     0   24.7    3.9   17.2        0  37922     .420     7.94       9
--------------------------------------------------------------------------------------
          CALCULATED GRAM/HR           WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2   FAC.      HP   ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------------
   1   0.0    54.9      174     1.8   .070     0.0       I       R        R        R
   2   0.0     7.8       70     5.6   .060      .1     0.0    8.50     76.3      6.2
   3   0.0     7.8       76     8.5   .060      .2     0.0    2.01     19.7      2.2
   4   0.0     2.4       92    21.2   .050      .4     0.0     .26     10.3      2.4
   5   0.0    35.8       99    42.4   .030      .4     0.0    2.90      8.0      3.4
   6   0.0    50.3      166   147.1   .060     1.5     0.0    2.04      6.7      6.0
   7   0.0    73.4      934   315.2  0.000     0.0     0.0    2.00     25.4      8.6
   8   0.0    69.3     1064   354.4   .040     1.6     0.0    1.71     26.3      8.8
   9   0.0    77.9     1060   442.0  0.000     0.0     0.0    1.72     23.4      9.8
  10   0.0   254.1    10071   214.8  0.000     0.0     0.0    5.11    198.6      4.2
  11   0.0    33.0      261     2.2   .070     0.0       I       R        R        R
  12   0.0   731.6      132      .4   .120     0.0       I       R        R        R
  13   0.0   515.6    21053   497.2   .025     2.7     0.0    4.71    192.3      4.5
  14   0.0   352.8    12900   385.3   .055     5.7     0.0    3.41    124.8      3.7
  15   0.0   308.6     7047   653.8   .035     3.2     0.0    3.36     76.6      7.1
  16   0.0   311.5     6288   685.6   .060     5.0     0.0    3.70     74.8      8.2
  17   0.0    55.7      384   551.7   .060     3.4     0.0     .99      6.8      9.8
  18   0.0    35.0      303   195.7  0.000     0.0     0.0    1.25     10.8      7.0
  19   0.0    14.3      188    74.3   .065     1.3     0.0     .71      9.4      3.7
  20   0.0     8.2      136    37.0  0.000     0.0     0.0     .89     14.8      4.0
  21   0.0     5.8      114    21.5  0.000     0.0     0.0    2.66     51.9      9.8
  22   0.0    38.0      189     2.2   .080     0.0       I       R        R        R
  23   0.0   552.0      124      .4   .060     0.0       I       R        R        R

CYCLE COMPOSITE     HC       7.984    GRAM/BHP HR
                    CO      79.529    GRAM/BHP HR
                    NO2      6.349    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .680      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
6-13-72 RUN 2  1973 CALIFORNIA VERSION OF ENGINE 2-3  PER MANUF. SPECS.
--------------------------------------------------------------------------------
                 DYNA.        MAN.  FUEL    A/F                DRY CONCENTRATION
MODE SPEED       LOAD    HP   VAC.  LB/HR   RATIO    ALDE.      HC       CO       CO2      NO
--------------------------------------------------------------------------------
  1    600        0.0     0   17.5    4.7    15.2          0   3162     .930    13.06     40
  2   1200        4.0     1   19.2    7.9    15.6          0    215     .130    13.91     73
  3   1200       17.0     4   18.5    8.4    16.1          0    474     .130    13.77    116
  4   1200       39.0     9   16.5   10.1    16.2          0    822     .130    13.48    250
  5   1200       54.0    12   15.2   10.9    16.3          0   1033     .130    13.18    400
  6   1200      108.0    25   10.0   15.9    16.4          0   1011     .130    13.18    830
  7   1200      161.0    37    5.6   21.7    14.9          0   1394     .640    13.77   1425
  8   1200      177.0    40    3.5   22.7    15.0          0   1269     .610    13.77   1500
  9   1200      198.0    45    2.9   24.6    14.8          0   1452     .580    13.91   1725
 10   1200      222.0    51    0.0   32.5    12.5          0   3089    5.240    11.24    775
 11    600        0.0     0   18.3    4.7    14.8          0   2719    1.300    13.06     42
 12   1200        0.0     0   22.0    3.8     9.0          0  55420     .470     6.64      6
 13   2300      252.0   110    0.0   64.8    12.3          0   2862    5.780    10.89    900
 14   2300      236.0   103    3.3   51.2    13.1          0   2503    3.790    12.22    875
 15   2300      210.0    92    5.0   48.5    13.7          0   2242    2.360    13.18   1425
 16   2300      192.0    84    6.0   46.5    13.8          0   2170    2.180    13.18   1563
 17   2300      128.0    56   10.0   31.2    16.0          0    455     .150    13.33   1625
 18   2300       64.0    28   15.2   21.4    16.1          0    382     .150    13.18    680
 19   2300       46.0    20   16.9   18.3    16.3          0    225     .130    13.18    350
 20   2300       21.0     4   18.9   15.4    16.2          0    124     .100    13.33    154
 21   2300        5.0     2   20.5   12.7    16.4          0    101     .070    13.18     98
 22    600        0.0     0   12.9    4.7    15.4          0   2928     .700    12.94     38
 23   2300        0.0     0   23.9    3.9    18.7          0  35258     .350     7.75      9
--------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2   FAC.      HP  ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0    47.1      280     2.0   .070     0.0      I       R        R        R
  2    0.0     5.5       67     6.1   .060      .1    0.0    5.99     73.2      6.7
  3    0.0    12.9       72    10.5   .060      .2    0.0    3.33     18.5      2.7
  4    0.0    27.5       88    27.8   .050      .4    0.0    3.09      9.9      3.1
  5    0.0    38.1       97    49.0   .030      .4    0.0    3.09      7.8      4.0
  6    0.0    54.4      141   148.2   .060     1.5    0.0    2.20      5.7      6.0
  7    0.0    94.3      875   320.1  0.000     0.0    0.0    2.56     23.8      8.7
  8    0.0    90.1      875   353.5   .040     1.6    0.0    2.23     21.6      8.7
  9    0.0   110.7      893   436.7  0.000     0.0    0.0    2.45     19.7      9.7
 10    0.0   271.2     9294   225.9  0.000     0.0    0.0    5.35    183.2      4.5
 11    0.0    39.6      383     2.0   .070     0.0      I       R        R        R
 12    0.0   755.0      129      .3   .120     0.0      I       R        R        R
 13    0.0   496.2    20239   518.0   .025     2.8    0.0    4.50    183.4      4.7
 14    0.0   357.5    10935   414.9   .055     5.7    0.0    3.46    105.8      4.0
 15    0.0   312.8     6653   660.2   .035     3.2    0.0    3.40     72.3      7.2
 16    0.0   293.8     5963   702.4   .060     5.0    0.0    3.49     70.9      8.4
 17    0.0    47.7      317   564.5   .060     3.4    0.0     .85      5.7     10.1
 18    0.0    27.7      220   163.9  0.000     0.0    0.0     .99      7.9      5.8
 19    0.0    14.0      163    72.3   .065     1.3    0.0     .69      8.1      3.6
 20    0.0     6.4      105    26.5  0.000     0.0    0.0     .70     11.4      2.9
 21    0.0     4.4       61    14.1  0.000     0.0    0.0    2.00     28.1      6.4
 22    0.0    44.8      216     1.9   .080     0.0      I       R        R        R
 23    0.0   536.5      108      .5   .060     0.0      I       R        R        R

CYCLE COMPOSITE     HC      8.105    GRAM/BHP HR
                    CO     73.193    GRAM/BHP HR
                    NO2     6.527    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .679      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
 6-15-72 RUN 1  1973 CALIFORNIA VERSION OF ENGINE 2-3  PER MANUF. SPECS.
----------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO    ALDE.    HC       CO      CO2      NO
----------------------------------------------------------------------------
  1   600      0.0     0   17.8   4.2   15.7        0   3947    .640    13.18     37
  2  1200      4.3     1   19.5   7.4   15.9        0    407    .100    14.05     60
  3  1200     17.2     4   19.4   7.5   15.6        0    815    .130    14.18     60
  4  1200     38.7     9   16.7   9.5   16.4        0    889    .130    13.48    219
  5  1200     53.8    12   15.5  10.8   16.4        0    957    .100    13.48    280
  6  1200    107.5    25   10.5  15.9   16.3        0   1036    .100    13.48    735
  7  1200    161.0    37    5.4  22.5   15.0        0   1339    .700    13.91   1275
  8  1200    177.0    40    3.4  23.2   15.1        0   1215    .640    14.05   1438
  9  1200    197.8    45    2.6  24.2   14.8        0   1604    .490    14.42   1775
 10  1200    222.0    51    0.0  32.2   12.6        0   3323   5.140    11.72    763
 11   600      0.0     0   18.3   4.3   15.1        0   3400    .930    13.48     43
 12  1200      0.0     0   22.0   3.8   17.3        0  53928    .470     6.64      7
 13  2300    258.0   113    0.0  66.5   12.4        0   3179   5.720    11.13    963
 14  2300    235.0   103    3.0  53.0   13.4        0   2926   3.240    12.71   1150
 15  2300    209.9    92    4.7  47.0   13.9        0   2917   1.940    13.63   1688
 16  2300    192.0    84    5.9  44.5   14.0        0   2715   1.840    13.63   1675
 17  2300    128.0    56    9.8  32.5   16.0        0    934    .130    13.48   1537
 18  2300     64.0    26   15.5  21.2   16.1        0    574    .150    13.48    838
 19  2300     46.0    20   17.0  18.5   16.1        0    377    .100    13.48    500
 20  2300     21.0     9   19.0  15.2   16.2        0    202    .070    13.33    245
 21  2300      5.0     2   20.2  12.2   16.2        0    200    .050    13.48    129
 22   600      0.0     0   18.0   3.8   15.6        0   2481    .470    13.33     43
 23  2300      0.0     0   24.0   4.0   17.8        0  33506    .310     8.43      7
----------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO      NO2   FAC.      HP  ALDE.      HC      CO     NO2
----------------------------------------------------------------------------
  1   0.0    52.9     173      1.6  .070      0.0     I        R       R       R
  2   0.0     9.6      48      4.8  .060       .1   0.0     9.80    48.6     4.8
  3   0.0    19.3      62      4.7  .060       .2   0.0     4.90    15.8     1.2
  4   0.0    28.0      83     22.8  .050       .4   0.0     3.16     9.3     2.6
  5   0.0    34.3      72     33.3  .030       .4   0.0     2.79     5.9     2.7
  6   0.0    54.6     106    128.6  .060      1.5   0.0     2.22     4.3     5.2
  7   0.0    92.7     979    293.0 0.000      0.0   0.0     2.52    26.6     8.0
  8   0.0    86.4     919    339.1  .040      1.6   0.0     2.14    22.7     8.4
  9   0.0   116.4     721    429.2 0.000      0.0   0.0     2.59    16.0     9.5
 10   0.0   282.3    8821    215.1 0.000      0.0   0.0     5.57   173.9     4.2
 11   0.0    45.0     248      1.9  .070      0.0     I        R       R       R
 12   0.0   743.5     131       .3  .120      0.0     I        R       R       R
 13   0.0   558.5   20301    561.5  .025      2.8   0.0     4.94   179.7     5.0
 14   0.0   433.1    9687    565.1  .055      5.7   0.0     4.21    94.1     5.5
 15   0.0   342.1    5267    753.0  .035      3.2   0.0     4.27    57.3     8.2
 16   0.0   348.1    4766    713.1  .060      5.0   0.0     4.14    56.7     8.5
 17   0.0   100.5     283    549.1  .060      3.4   0.0     1.79     5.0     9.8
 18   0.0    40.3     213    195.3 0.000      0.0   0.0     1.44     7.6     7.0
 19   0.0    23.2     124    102.3  .065      1.3   0.0     1.15     6.2     5.1
 20   0.0    10.4      73     41.8 0.000      0.0   0.0     1.13     7.9     4.5
 21   0.0     8.2      41     17.5 0.000      0.0   0.0     3.73    18.8     8.0
 22   0.0    30.4     116      1.7  .080      0.0     I        R       R       R
 23   0.0   502.8      94       .4  .060      0.0     I        R       R       R

CYCLE COMPOSITE    HC      8.569   GRAM/BHP HR
                   CO     64.484   GRAM/BHP HR
                   NO2     6.960   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .672     LB/BHP HR
```

APPENDIX H

ENGINE 2-3

EFFECT OF TIMING ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 2-3

EFFECT OF TIMING ON EMISSIONS

TABULAR DATA

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
 6-16-72 RUN 3       1972 VERSION OF ENGINE  2-3     TIMING 25  BTDC
---------------------------------------------------------------------------------------
               DYNA.        MAN. FUEL     A/F                 DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR   RATIO   ALDE.     HC       CO       CO2     NO
---------------------------------------------------------------------------------------
   1   750      0.0     0  20.0    3.8    13.5       0  13943     .640    11.84     58
   2  1200      5.0     1  20.6    5.7    15.6       0   9639     .350    12.71     68
   3  1200     20.0     5  19.5    6.9    15.6       0   1355     .180    13.77    163
   4  1200     46.0    11  18.0    8.0    15.7       0   2170     .130    13.63   1075
   5  1200     64.0    15  16.5    9.8    15.9       0   2305     .100    13.33   2262
   6  1200    128.0    29  10.1   14.8    17.0       0   2009     .100    12.47   3150
   7  1200    192.0    44   6.0   20.5    15.3       0   2342     .130    13.77   4200
   8  1200    210.0    48   4.0   21.2    14.9       0   2462     .520    13.77   3200
   9  1200    236.0    54   1.8   24.5    14.8       0   2397     .520    13.33   3000
  10  1200    256.0    58    .3   32.2    12.6       0   3878    5.560    10.55   1675
  11   750      0.0     0  20.8    3.6    14.4       0   3234    1.520    13.06     71
  12  1200      0.0     0  22.4    3.7    19.3       0  33600    1.090     8.93     13
  13  2300    266.0   116    .4   64.2    12.1       0   3640    6.570    10.25   1387
  14  2300    245.0   107   2.4   50.0    13.8       0   2457    2.480    12.94   2175
  15  2300    218.0    95   4.4   44.5    14.5       0   2092    1.450    13.33   3500
  16  2300    200.0    88   5.8   41.2    14.6       0   2022    1.340    13.33   3550
  17  2300    133.0    58  10.1   29.8    16.6       0   1064     .210    12.71   4200
  18  2300     67.0    29  15.7   19.0    16.6       0   1024     .210    12.71   2650
  19  2300     48.0    21  17.7   15.5    16.4       0    841     .180    12.94   1350
  20  2300     21.0     9  20.0   13.2    16.4       0   1121     .180    12.94    520
  21  2300      5.0     2  21.2    9.2    16.4       0   9244     .210    12.09    113
  22   750      0.0     0  20.2    3.6    15.1       0   3729     .890    13.18     44
  23  2300      0.0     0  24.1    4.2    17.4       0  55463     .470     6.73      8
---------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP  ALDE.       HC       CO      NO2
---------------------------------------------------------------------------------------
   1   0.0  173.2      161     2.4   .070     0.0      I        R        R        R
   2   0.0  177.7      130     4.2   .060      .1    0.0   155.55    114.1      3.6
   3   0.0   30.1       81    12.0   .060      .3    0.0     6.59     17.7      2.6
   4   0.0   56.3       68    92.7   .050      .5    0.0     5.36      6.5      8.8
   5   0.0   75.0       66   244.4   .030      .4    0.0     5.13      4.5     16.7
   6   0.0  105.6      106   549.7   .060     1.8    0.0     3.61      3.6     18.8
   7   0.0  154.1      173   917.4  0.000     0.0    0.0     3.51      3.9     20.9
   8   0.0  162.9      695   702.8   .040     1.9    0.0     3.40     14.5     14.6
   9   0.0  189.1      828   785.6  0.000     0.0    0.0     3.51     15.4     14.6
  10   0.0  343.3     9943   492.3  0.000     0.0    0.0     5.87    170.0      8.4
  11   0.0   35.4      336     2.6   .070     0.0      I        R        R        R
  12   0.0  421.5      276      .6   .120     0.0      I        R        R        R
  13   0.0  616.9    22491   760.6   .025     2.9    0.0     5.30    193.1      6.7
  14   0.0  355.7     7253  1045.4   .055     5.9    0.0     3.31     67.6      9.7
  15   0.0  281.7     3944  1564.8   .035     3.3    0.0     2.95     41.3     16.4
  16   0.0  254.0     3401  1481.0   .060     5.3    0.0     2.90     38.8     16.9
  17   0.0  110.4      440  1447.0   .060     3.5    0.0     1.89      7.6     24.8
  18   0.0   67.8      281   582.3  0.000     0.0    0.0     2.31      9.6     19.8
  19   0.0   44.8      194   238.7   .065     1.4    0.0     2.13      9.2     11.4
  20   0.0   50.7      165    78.1  0.000     0.0    0.0     5.52     17.9      8.5
  21   0.0  291.7      134    11.8  0.000     0.0    0.0   133.23     61.1      5.4
  22   0.0   42.2      203     1.7   .080     0.0      I        R        R        R
  23   0.0  829.0      142      .4   .060     0.0      I        R        R        R

CYCLE COMPOSITE     HC       8.010    GRAM/BHP HR
                    CO      54.573    GRAM/BHP HR
                    NO2     14.589    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .582      LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
 6-16-72 RUN 2        1972 VERSION OF ENGINE  2-3     TIMING 16  BTDC
-------------------------------------------------------------------------------
              DYNA.         MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO   ALDE.     HC       CO       CO2     NO
-------------------------------------------------------------------------------
  1    735     0.0     0   19.8   3.8    15.5       0   2487     .640     13.48     41
  2   1200     5.0     1   21.0   5.9    15.8       0   1779     .210     13.77     58
  3   1200    20.0     5   19.2   7.2    15.6       0    815     .150     14.05    130
  4   1200    45.0    10   18.0   8.3    15.6       0   1943     .130     13.91    900
  5   1200    63.0    14   16.5   9.9    15.8       0   2166     .100     13.77   1600
  6   1200   126.0    29   10.4  15.1    14.6       0   1819     .100     13.18   2800
  7   1200   189.0    43    6.4  19.9    15.2       0   2155     .180     14.31   3300
  8   1200   207.0    47    4.3  21.4    15.4       0   2014     .150     14.05   3850
  9   1200   232.0    53    2.0  23.7    15.3       0   2014     .150     14.05   4150
 10   1200   252.0    58     .1  32.3    12.6       0   3607    5.670     11.01   1500
 11    735     0.0     0   20.3   3.7    14.8       0   2159    1.090     13.63     52
 12   1200     0.0     0   22.4   3.8    16.1       0  40248     .890      8.60     11
 13   2300   265.0   116     .3  66.0    11.9       0   6005    6.640     10.09   1275
 14   2300   244.0   107    2.7  49.5    14.3       0   2309    1.700     13.48   2750
 15   2300   217.0    95    4.5  44.0    14.6       0   2056    1.380     13.33   3300
 16   2300   199.0    87    6.2  41.6    14.7       0   1999    1.230     13.48   3400
 17   2300   133.0    58   10.0  29.7    16.7       0    973     .150     12.59   3650
 18   2300    66.0    29   15.9  19.5    16.8       0    929     .150     12.71   2300
 19   2300    48.0    21   17.6  16.7    16.7       0    750     .150     12.71   1450
 20   2300    21.0     9   20.1  12.6    16.5       0    426     .150     12.94    470
 21   2300     5.0     2   21.1   9.4    16.6       0   1678     .150     12.71    155
 22    735     0.0     0   19.9   3.5    15.4       0   2087     .670     13.18     48
 23   2300     0.0     0   24.0   4.4    17.5       0  51730     .470      6.73      7
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------
  1   0.0    29.8     155     1.7  .070      0.0      I       R        R       R
  2   0.0    33.6      80     3.6  .060       .1    0.0   29.43     70.2     3.2
  3   0.0    18.6      69     9.9  .060       .3    0.0    4.08     15.2     2.2
  4   0.0    51.4      69    79.0  .050       .5    0.0    5.00      6.8     7.7
  5   0.0    69.1      64   169.3  .030       .4    0.0    4.80      4.5    11.8
  6   0.0    92.6     103   473.0  .060      1.7    0.0    3.21      3.6    16.4
  7   0.0   132.3     223   672.5 0.000      0.0    0.0    3.06      5.2    15.6
  8   0.0   135.7     204   861.6  .040      1.9    0.0    2.87      4.3    18.2
  9   0.0   150.3     226  1028.5 0.000      0.0    0.0    2.84      4.3    19.4
 10   0.0   310.1    9847   428.2 0.000      0.0    0.0    5.39    171.0     7.4
 11   0.0    24.3     247     1.9  .070      0.0      I       R        R       R
 12   0.0   513.3     229      .5  .120      0.0      I       R        R       R
 13   0.0  1037.3   23170   731.2  .025      2.9    0.0    8.94    199.7     6.3
 14   0.0   336.5    5003  1330.2  .055      5.9    0.0    3.15     46.8    12.4
 15   0.0   275.1    3730  1466.0  .035      3.3    0.0    2.90     39.3    15.4
 16   0.0   253.1    3144  1428.6  .060      5.2    0.0    2.90     36.1    16.4
 17   0.0   102.1     318  1271.7  .060      3.5    0.0    1.75      5.5    21.8
 18   0.0    63.4     207   521.4 0.000      0.0    0.0    2.19      7.2    18.0
 19   0.0    43.9     177   281.9  .065      1.4    0.0    2.09      8.4    13.4
 20   0.0    18.5     132    67.9 0.000      0.0    0.0    2.02     14.3     7.4
 21   0.0    54.9      99    16.8 0.000      0.0    0.0   25.09     45.3     7.7
 22   0.0    23.6     153     1.8  .080      0.0      I       R        R       R
 23   0.0   834.4     153      .4  .060      0.0      I       R        R       R

CYCLE COMPOSITE    HC       7.908    GRAM/BHP HR
                   CO      48.339    GRAM/BHP HR
                   NO2     14.621    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .593      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-19-72 RUN 2        ENG. 2-3,  1972 VERSION,  TIMING 4 ATDC
------------------------------------------------------------------------------------------------
              DYNA.          MAN. FUEL    A/F                   DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO    ALDE.     HC        CO       CO2      NO
------------------------------------------------------------------------------------------------
   1   680     0.0     0  16.6   5.5    15.3        0    921      .440     14.05      78
   2  1200     3.6     1  18.5   7.6    15.4        0    233      .180     14.53      93
   3  1200    14.5     3  18.0   7.9    16.1        0    387      .130     13.77     107
   4  1200    33.0     8  16.1   9.6    16.2        0    664      .100     13.48     227
   5  1200    46.0    11  15.4  10.5    16.4        0    721      .100     13.63     300
   6  1200    91.0    21  18.0  17.1    16.1        0    282      .100     13.91     570
   7  1200   137.0    31   4.6  21.5    15.2        0    534      .150     14.66    1150
   8  1200   149.0    34   3.0  22.9    15.1        0    677      .310     14.53    1200
   9  1200   167.0    38   1.7  24.5    15.1        0    774      .390     14.53    1350
  10  1200   182.0    42    .3  32.1    12.6        0   2214     5.450     11.60     630
  11   680     0.0     0  17.3   5.1    14.9        0   1055      .640     14.53      82
  12  1200     0.0     0  20.9   5.8    15.9        0  25491      .700     11.01      19
  13  2300   222.0    97    .7  64.3    12.1        0   2716     6.310     10.55     590
  14  2300   204.0    89   2.6  50.5    13.6        0   1805     2.870     12.94     963
  15  2300   182.0    80   4.4  44.5    14.4        0    883     1.340     13.77    1438
  16  2300   167.0    73   5.1  43.2    14.4        0    840     1.410     13.63    1300
  17  2300   111.0    49   8.8  31.6    16.4        0    120      .070     12.94     975
  18  2300    56.0    25  16.0  19.3    16.4        0    181      .100     12.94     720
  19  2300    40.0    18  17.4  17.5    16.6        0    136      .100     12.94     425
  20  2300    18.0     8  19.2  13.0    16.4        0     72      .100     13.18     200
  21  2300    44.0    19  20.7  10.5    16.1        0    104      .070     13.48     102
  22   680     0.0     0  16.5   4.8    15.5        0    440      .180     13.77      83
  23  2300     0.0     0  23.6   5.7    17.4        0  27427      .390      8.93      12
------------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO     NO2  FAC.       HP  ALDE.      HC      CO      NO2
------------------------------------------------------------------------------------------------
   1   0.0    15.8     152     4.4  .070      0.0      I       R       R       R
   2   0.0     5.4      85     7.2  .060       .0    0.0    6.63   103.4     8.7
   3   0.0     9.9      68     9.2  .060       .2    0.0    3.00    20.4     2.8
   4   0.0    21.2      64    24.1  .050       .4    0.0    2.81     8.5     3.2
   5   0.0    24.9      70    34.4  .030       .3    0.0    2.37     6.6     3.3
   6   0.0    15.6     112   104.6  .060      1.2    0.0     .75     5.4     5.0
   7   0.0    35.1     199   250.5 0.000      0.0    0.0    1.12     6.4     8.0
   8   0.0    47.1     436   277.6  .040      1.4    0.0    1.38    12.8     8.2
   9   0.0    57.3     584   332.1 0.000      0.0    0.0    1.50    15.3     8.7
  10   0.0   186.7    9281   176.3 0.000      0.0    0.0    4.49   223.2     4.2
  11   0.0    16.0     196     4.1  .070      0.0      I       R       R       R
  12   0.0   470.3     261     1.1  .120      0.0      I       R       R       R
  13   0.0   462.5   21700   333.5  .025      2.4    0.0    4.76   223.2     3.4
  14   0.0   258.6    8305   457.8  .055      4.9    0.0    2.89    93.0     5.1
  15   0.0   117.3    3595   633.8  .035      2.8    0.0    1.47    45.1     8.0
  16   0.0   108.8    3690   559.2  .060      4.4    0.0    1.49    50.5     7.6
  17   0.0    13.3     156   356.3  .060      2.9    0.0     .27     3.2     7.3
  18   0.0    12.1     135   160.3 0.000      0.0    0.0     .49     5.5     6.5
  19   0.0     8.3     123    85.8  .065      1.1    0.0     .47     7.0     4.9
  20   0.0     3.2      90    29.5 0.000      0.0    0.0     .41    11.4     3.7
  21   0.0     3.7      50    12.0 0.000      0.0    0.0     .19     2.6      .6
  22   0.0     6.9      57     4.3  .080      0.0      I       R       R       R
  23   0.0   587.9     169      .8  .060      0.0      I       R       R       R

CYCLE COMPOSITE    HC       6.227    GRAM/BHP HR
                   CO      66.561    GRAM/BHP HR
                   NO2      6.234    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .786      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
 6-19-72 RUN 1  1972 VERS. ENG. 2-3  TIM. 12  ATDC  DIST. VAC. CONNECTED
----------------------------------------------------------------------------------
             DYNA.          MAN.  FUEL     A/F              DRY CONCENTRATION
MODE SPEED   LOAD     HP   VAC.  LB/HR   RATIO    ALDE.     HC       CO       CO2     NO
----------------------------------------------------------------------------------
  1    560     0.0     0   13.0    5.0    16.6        0  15110     .280     11.72     69
  2   1200     2.4     1   18.0    7.5    16.2        0    147     .100     13.63     75
  3   1200    10.0     2   17.5    8.3    16.3        0    149     .100     13.48     81
  4   1200    22.0     5   16.2   10.0    16.5        0    199     .100     13.18    122
  5   1200    31.0     7   14.6   10.6    16.5        0    223     .100     13.18    152
  6   1200    61.0    14    6.8   18.8    15.4        0    144     .100     14.18    620
  7   1200    92.0    21    3.1   22.5    15.3        0    207     .180     14.05    795
  8   1200   100.0    23    2.6   23.0    15.2        0    215     .150     14.18    880
  9   1200   112.0    26    1.4   25.2    14.9        0    454     .490     14.18    913
 10   1200   122.0    28     .3   32.5    12.6        0   1933    5.400     11.24    400
 11    560     0.0     0   14.5    4.6    14.6        0   1621    1.090     13.77     77
 12   1200     0.0     0   20.7    5.2    16.8        0  28946     .610      9.37      9
 13   2300   174.0    76     .6   64.8    12.1        0   2067    6.370     10.55    300
 14   2300   160.0    70    2.7   47.5    14.5        0    455     .850     14.05    810
 15   2300   143.0    63    3.5   46.6    14.2        0    642    1.380     13.91    720
 16   2300   131.0    57    4.4   45.3    14.3        0    577    1.270     13.91    660
 17   2300    87.0    38    7.7   35.8    15.3        0    133     .100     14.18    735
 18   2300    44.0    19   15.0   20.5    16.3        0    111     .070     13.18    420
 19   2300    31.0    14   16.5   18.8    16.5        0     88     .070     13.18    280
 20   2300    14.0     6   18.3   15.5    16.4        0     58     .070     13.18    155
 21   2300     3.4     1   19.7   13.2    16.3        0     37     .050     13.48     90
 22    560     0.0     0   13.5    4.8    15.5        0    678     .210     13.91     91
 23   2300     0.0     0   23.4    5.5    12.4        0  29273     .350      8.75     12
----------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2   FAC.       HP   ALDE.      HC       CO      NO2
----------------------------------------------------------------------------------
  1   0.0   253.6       95      3.8   .070      0.0      I        R        R        R
  2   0.0     3.6       50      6.2   .060       .0    0.0     6.61     91.2     11.2
  3   0.0     4.1       56      7.5   .060       .1    0.0     1.81     24.5      3.3
  4   0.0     6.8       69     13.9   .050       .3    0.0     1.35     13.7      2.8
  5   0.0     8.1       73     18.3   .030       .2    0.0     1.14     10.3      2.6
  6   0.0     8.6      121    122.8   .060       .8    0.0      .62      8.6      8.8
  7   0.0    14.8      260    189.0  0.000      0.0    0.0      .70     12.4      9.0
  8   0.0    15.6      220    212.4   .040       .9    0.0      .68      9.6      9.3
  9   0.0    35.3      769    235.3  0.000      0.0    0.0     1.38     30.0      9.2
 10   0.0   169.3     9553    116.3  0.000      0.0    0.0     6.07    342.7      4.2
 11   0.0    22.5      306      3.6   .070      0.0      I        R        R        R
 12   0.0   530.3      226       .5   .120      0.0      I        R        R        R
 13   0.0   354.8    22083    170.9   .025      1.9    0.0     4.66    289.8      2.2
 14   0.0    65.6     2475    387.7   .055      3.9    0.0      .94     35.3      5.5
 15   0.0    88.4     3838    329.1   .035      2.2    0.0     1.41     61.3      5.3
 16   0.0    77.8     3459    295.5   .060      3.4    0.0     1.36     60.3      5.2
 17   0.0    15.1      229    277.2   .060      2.3    0.0      .40      6.0      7.3
 18   0.0     7.8       99     97.8  0.000      0.0    0.0      .40      5.1      5.1
 19   0.0     5.6       91     59.8   .065       .9    0.0      .41      6.7      4.4
 20   0.0     3.1       75     27.3  0.000      0.0    0.0      .50     12.2      4.5
 21   0.0     1.6       45     13.2  0.000      0.0    0.0     1.09     30.0      8.9
 22   0.0    10.4       65      4.6   .080      0.0      I        R        R        R
 23   0.0   607.2      147       .8   .060      0.0      I        R        R        R

CYCLE COMPOSITE     HC       8.494    GRAM/BHP HR
                    CO      67.687    GRAM/BHP HR
                    NO2      5.565    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC     1.049      LB/BHP HR
```

```
                   PROJECT 11-2877-01  CONTROL TECHNOLOGY
 6-16-72 RUN 4  1972 VERS. ENG. 2-3  TIM. 12  ATDC  DIST. VAC. DISSCON.
------------------------------------------------------------------------------------------
              DYNA.          MAN.  FUEL    A/F                DRY CONCENTRATION
MODE SPEED    LOAD    HP    VAC.  LB/HR   RATIO    ALDE.     HC       CO       CO2     NO
------------------------------------------------------------------------------------------
  1    535     0.0     0   13.8    5.0    15.4        0     871     .420    13.77     90
  2   1200     3.0     1   13.3   12.5    16.9        0     118     .050    12.94     91
  3   1200    10.0     2   12.0   13.0    16.9        0      56     .050    12.94    119
  4   1200    23.0     5   11.5   13.8    16.9        0      43     .050    12.94    127
  5   1200    33.0     8    8.5   17.3    16.3        0      37     .050    13.33    320
  6   1200    65.0    15    6.3   19.8    15.2        0     126     .130    14.31    735
  7   1200    98.0    22    3.0   23.3    21.1        0     179     .130    14.31    975
  8   1200   107.0    24    2.2   24.5    15.0        0     315     .390    14.18    938
  9   1200   120.0    27     .9   25.4    14.8        0     426     .550    14.18    938
 10   1200   130.0    30    0.0   31.6    12.6        0    1802    5.290    11.48    400
 11    535     0.0     0    0.0    5.2    20.8        0    1020     .550    13.91     90
 12   1200     0.0     0   21.0    5.5    11.8        0   34011     .520     9.03     14
 13   2300   178.0    78     .4   65.5    11.9        0    2343    6.710    10.25    220
 14   2300   164.0    72    2.6   51.2    13.6        0    1555    2.600    12.94    500
 15   2300   146.0    64    3.3   47.2    14.2        0     798    1.450    13.63    780
 16   2300   134.0    59    4.5   46.0    14.3        0     694    1.270    13.63    720
 17   2300    89.0    39    7.8   36.0    15.2        0     167     .100    14.05    680
 18   2300    45.0    20    9.5   29.5    16.7        0     118     .050    12.94    270
 19   2300    32.0    14   11.1   27.5    16.8        0      96     .050    12.94    235
 20   2300    14.0     6   14.4   22.5    16.6        0      73     .050    12.94    180
 21   2300     4.0     2   16.5   17.5    16.5        0      53     .050    13.06    110
 22    535     0.0     0   14.2    4.0    15.4        0     543     .210    13.91     98
 23   2300     0.0     0   23.2    5.5    18.1        0   25237     .310     8.93     15
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP   ALDE.      HC       CO     NO2
------------------------------------------------------------------------------------------
  1   0.0    13.8      135     4.8  .070      0.0       I       R        R       R
  2   0.0     5.1       44    13.2  .060       .0     0.0    7.48     64.3    19.3
  3   0.0     2.5       46    17.9  .060       .1     0.0    1.11     20.1     7.8
  4   0.0     2.1       49    20.4  .050       .3     0.0     .39      9.3     3.9
  5   0.0     2.2       59    62.3  .030       .2     0.0     .29      7.9     8.3
  6   0.0     7.8      163   151.6  .060       .9     0.0     .53     11.0    10.2
  7   0.0    13.1      192   236.6 0.000      0.0     0.0     .58      8.6    10.6
  8   0.0    24.0      600   236.9  .040      1.0     0.0     .98     24.5     9.7
  9   0.0    33.2      866   242.7 0.000      0.0     0.0    1.21     31.6     8.9
 10   0.0   152.4     9036   112.3 0.000      0.0     0.0    5.13    304.2     3.8
 11   0.0    16.5      180     4.8  .070      0.0       I       R        R       R
 12   0.0   655.2      202      .9  .120      0.0       I       R        R       R
 13   0.0   404.8    23421   126.2  .025      1.9     0.0    5.19    300.5     1.6
 14   0.0   230.2     7771   245.6  .055      4.0     0.0    3.20    108.2     3.4
 15   0.0   112.6     4137   365.7  .035      2.2     0.0    1.76     64.7     5.7
 16   0.0    96.7     3576   333.2  .060      3.5     0.0    1.65     60.9     5.7
 17   0.0    19.2      233   260.2  .060      2.3     0.0     .49      6.0     6.7
 18   0.0    12.1      104    92.3 0.000      0.0     0.0     .61      5.3     4.7
 19   0.0     9.2       97    74.9  .065       .9     0.0     .66      6.9     5.3
 20   0.0     5.7       79    46.9 0.000      0.0     0.0     .93     12.9     7.7
 21   0.0     3.2       61    22.1 0.000      0.0     0.0    1.82     34.9    12.6
 22   0.0     6.9       54     4.1  .080      0.0       I       R        R       R
 23   0.0   535.2      133     1.1  .060      0.0       I       R        R       R

CYCLE COMPOSITE      HC      8.585    GRAM/BHP HR
                     CO     85.680    GRAM/BHP HR
                     NO2     5.414    GRAM/BHP HR
                     ALDE    0.000    GRAM/BHP HR
                     BSFC    1.132      LB/BHP HR
```

ENGINE 2-3

EFFECT OF TIMING ON EMISSIONS

GRAPHED RESULTS

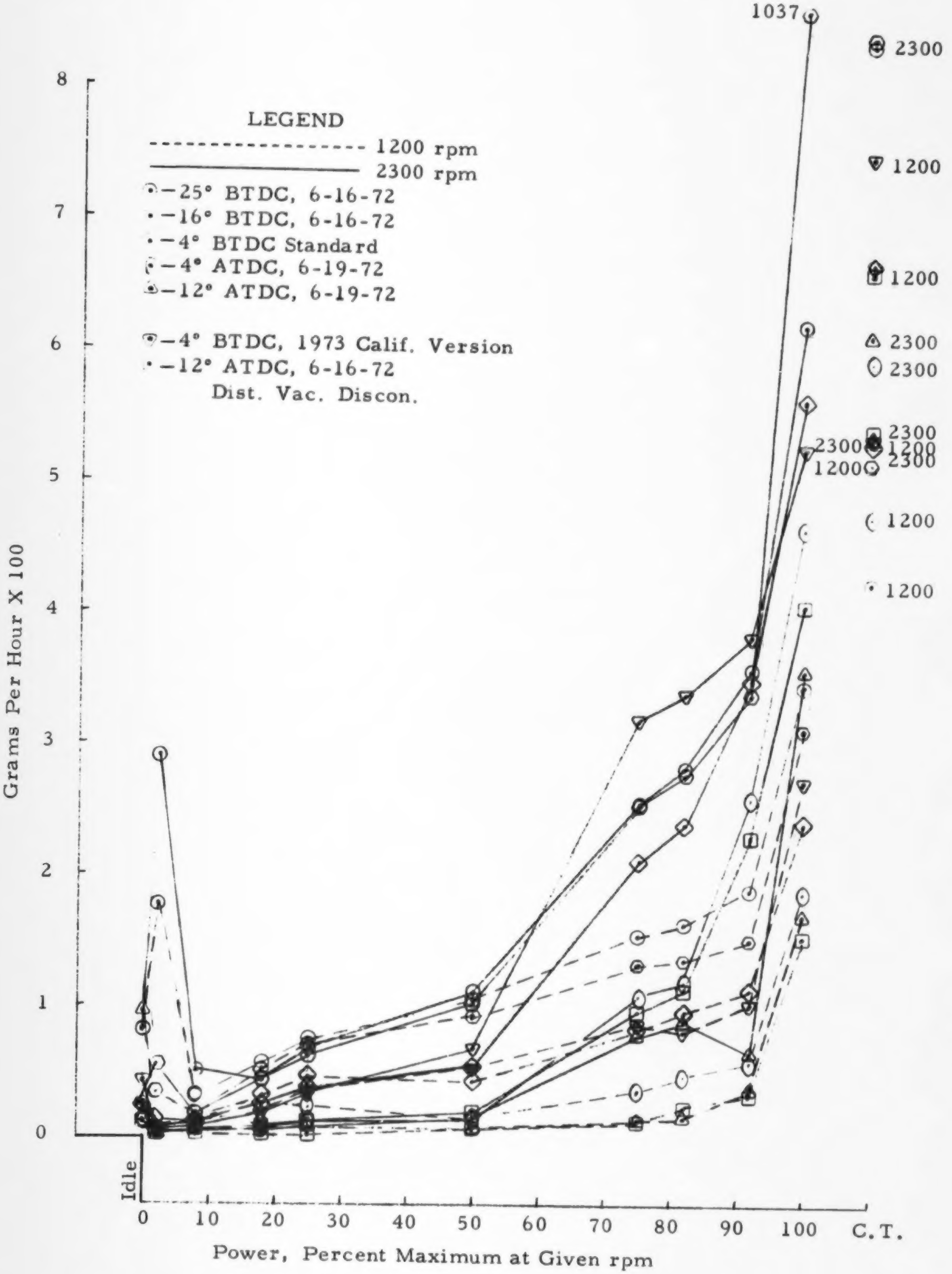


FIGURE H-1. EFFECT OF POWER ON HC EMISSION RATE

ENGINE 2-3, 23 MODE TEST

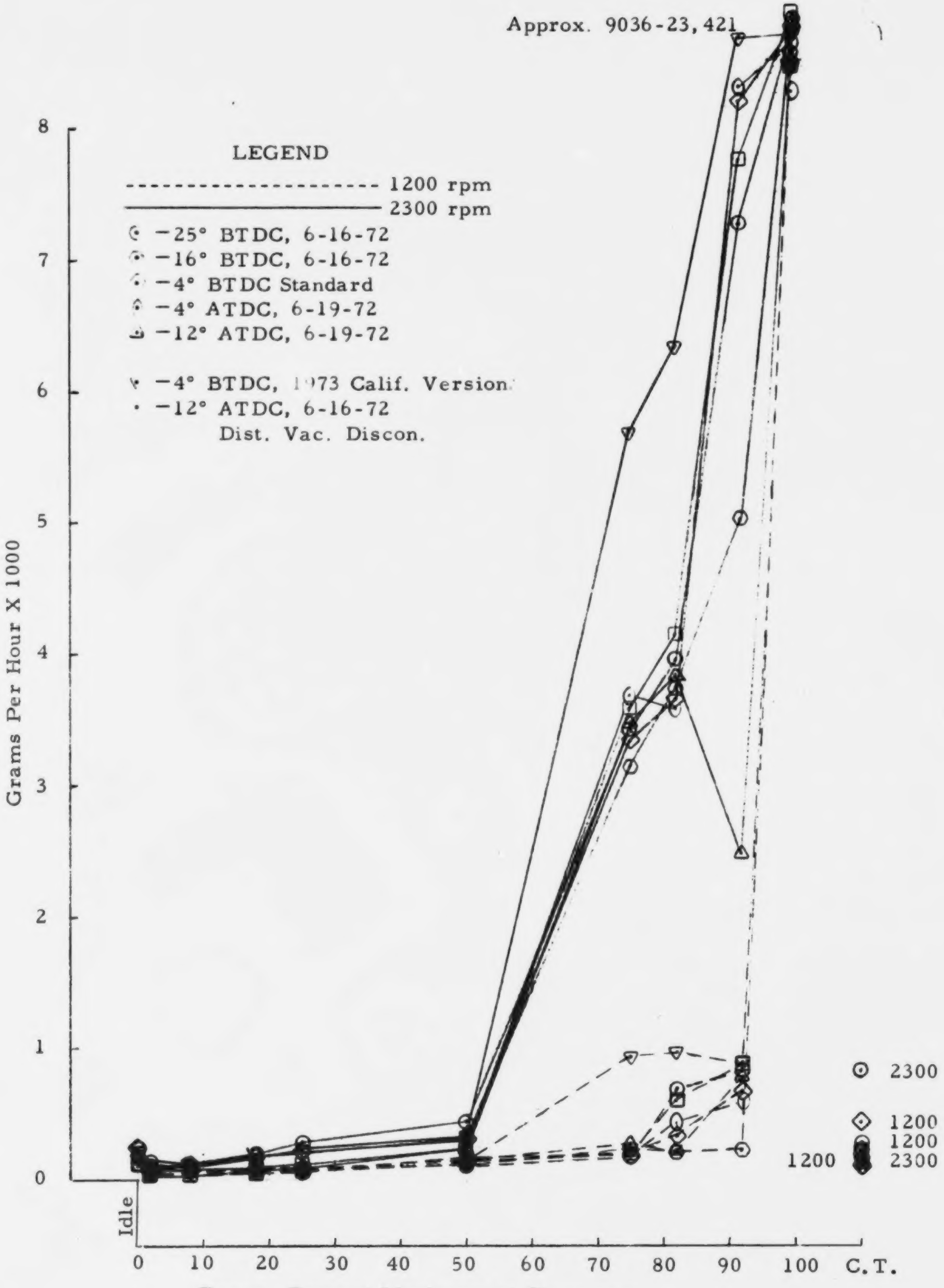


FIGURE H-2. EFFECT OF POWER ON CO EMISSION RATE
ENGINE 2-3, 23 MODE TEST

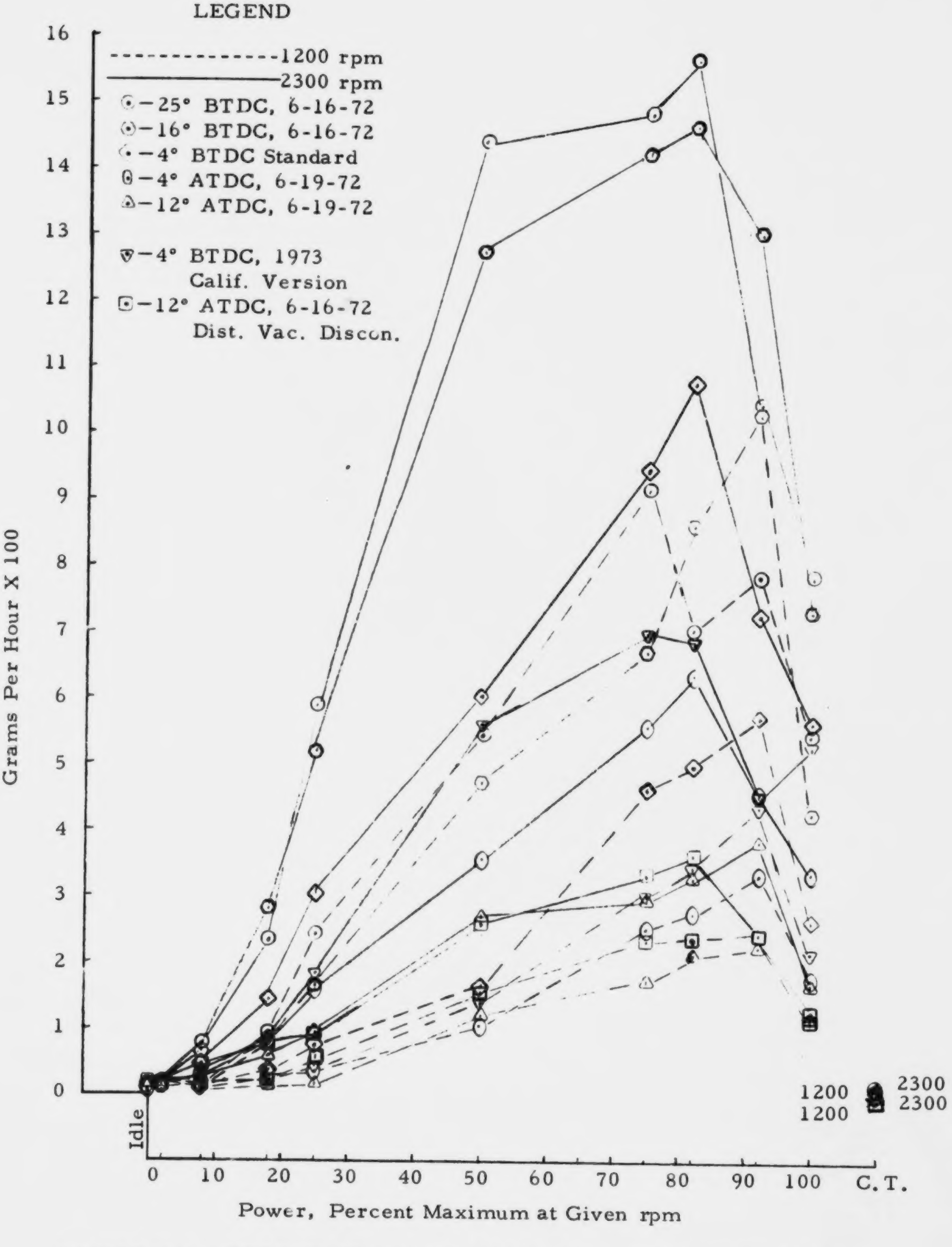


FIGURE H-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE

ENGINE 2-3, 23 MODE TEST

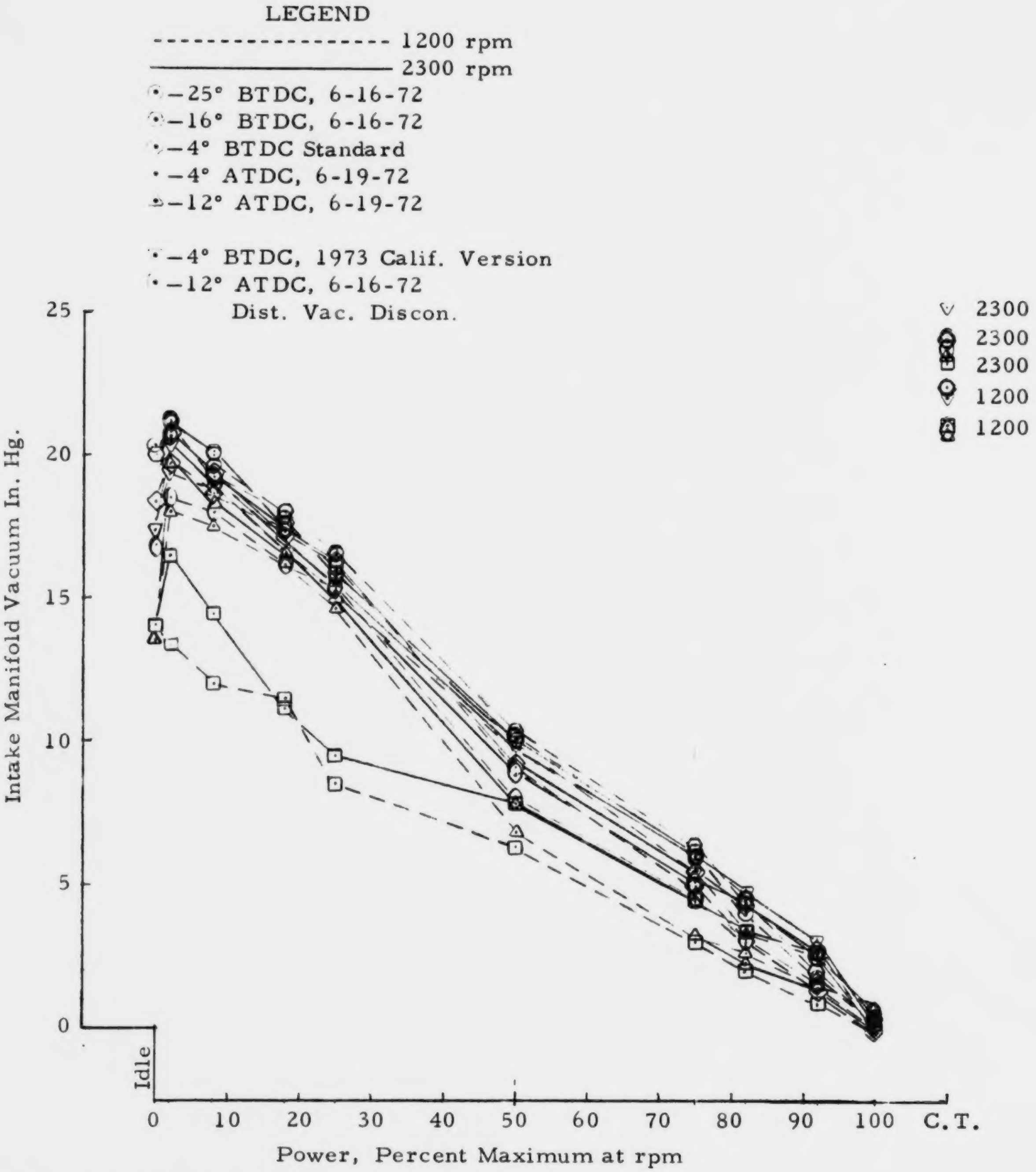


FIGURE H-4. MANIFOLD VACUUM AS A FUNCTION OF POWER

ENGINE 2-3, 23 MODE TEST

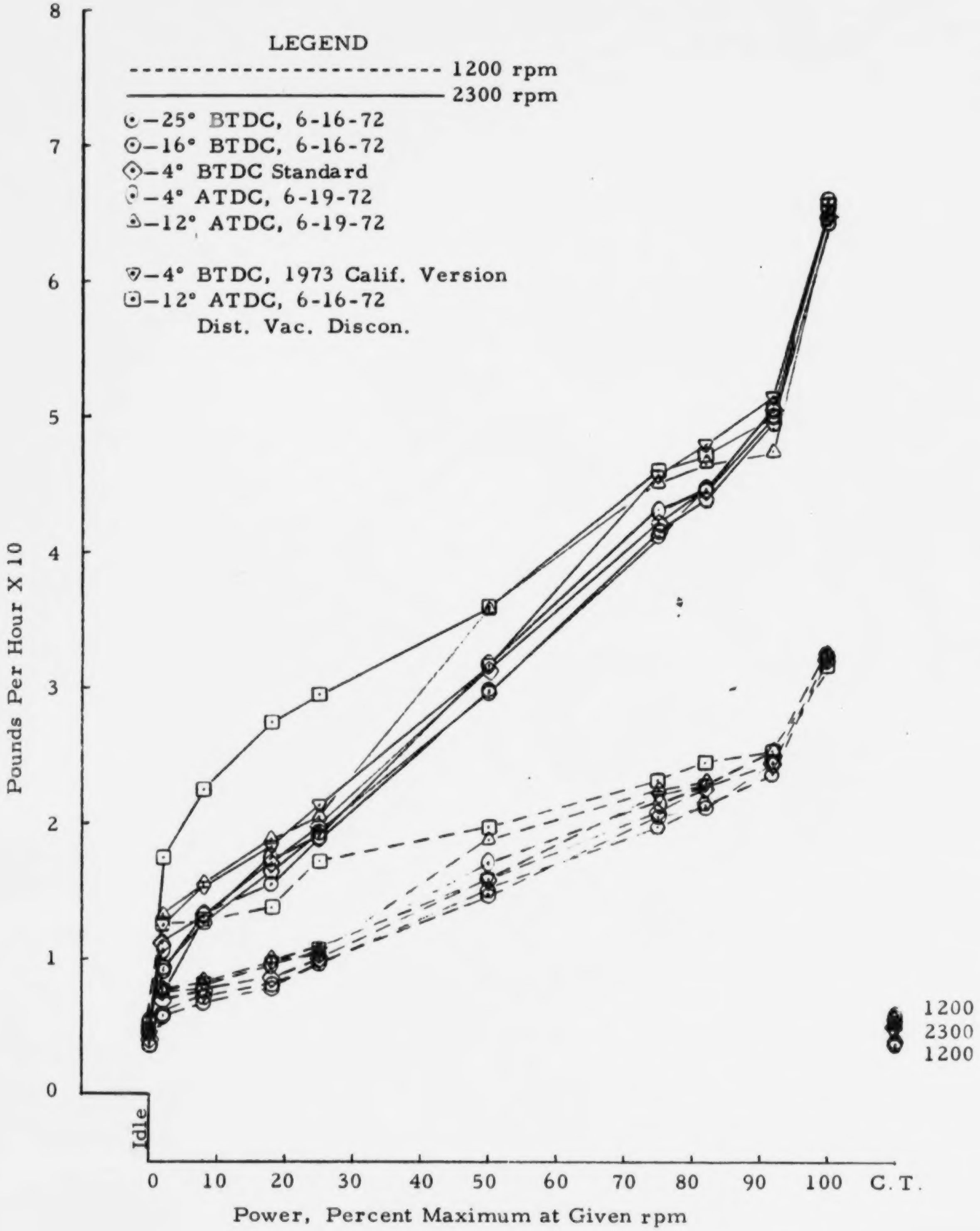


FIGURE H-5. FUEL CONSUMPTION AS A FUNCTION OF POWER

ENGINE 2-3, 23 MODE TEST

APPENDIX I

ENGINE 2-3

EFFECT OF AIR-FUEL RATIO ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 2-3

EFFECT OF AIR-FUEL RATIO ON EMISSIONS

TABULAR DATA

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-20-72 RUN 1   ENG. 2-3, PER MAN. SPECS.,   CARB. JETS .080 RODS .051
----------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F             DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2    NO
----------------------------------------------------------------------------
  1   680      0.0     0  18.0   3.5   14.9       0  2775   1.300   13.06    32
  2  1200      4.3     1  19.5   6.8   14.5       0   939   1.200   13.77    63
  3  1200     17.0     4  18.8   8.0   14.3       0  1370   1.520   13.77    91
  4  1200     39.0     9  18.2   8.8   14.4       0  1851   1.270   13.77   161
  5  1200     54.0    12  17.1   9.5   14.4       0  2165   1.160   13.91   420
  6  1200    108.0    25  12.2  14.3   15.2       0  1811    .180   14.05  1412
  7  1200    162.0    37   7.0  23.2   12.7       0  2826   4.880   11.72   410
  8  1200    177.0    40   5.4  27.5   11.6       0  3421   7.620    9.64   102
  9  1200    199.0    45   3.8  30.5   11.4       0  3569   8.010    9.37    99
 10  1200    216.0    49    .3  36.5   11.0       0  4717   9.060    8.75   177
 11   680      0.0     0  18.3   3.3   14.5       0  2444   1.840   12.94    34
 12  1200      0.0     0  22.8   3.5   16.1       0 56775    .970    6.73     3
 13  2300    256.0   112    .6  71.4   11.1       0  3701   9.060    8.84   305
 14  2300    236.0   103   2.7  67.7   10.6       0  3926  10.440    8.14    89
 15  2300    210.0    92   4.9  60.0   10.8       0  3779  10.030    8.54   152
 16  2300    192.0    84   6.7  50.3   12.1       0  3121   6.440   10.43   510
 17  2300    128.0    56  11.7  30.0   14.5       0  1705   1.120   13.63  2087
 18  2300     64.0    28  17.0  19.8   14.7       0  1560    .740   13.77  1313
 19  2300     46.0    20  18.6  16.5   14.7       0  1192    .810   13.77   550
 20  2300     20.0     9  20.3  13.5   14.8       0   763    .610   13.48   305
 21  2300      5.0     2  21.7  10.8   14.8       0   712    .640   13.48   134
 22   680      0.0     0  18.5   3.4   14.7       0  2515   1.480   12.59    48
 23  2300      0.0     0  24.7   3.6   17.3       0 43437    .470    7.37     7
----------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO     NO2  FAC.      HP  ALDE.      HC      CO     NO2
----------------------------------------------------------------------------
  1   0.0     30.1     285     1.2  .070     0.0      I       R       R       R
  2   0.0     19.2     496     4.3  .060      .1    0.0   19.57   505.2     4.4
  3   0.0     32.2     722     7.1  .060      .2    0.0    8.29   185.9     1.8
  4   0.0     48.5     673    14.0  .050      .4    0.0    5.45    75.5     1.6
  5   0.0     61.0     661    39.3  .030      .4    0.0    4.95    53.5     3.2
  6   0.0     81.5     164   211.1  .060     1.5    0.0    3.30     6.6     8.6
  7   0.0    176.2    6145    84.8 0.000     0.0    0.0    4.76   166.0     2.3
  8   0.0    242.4   10908    24.1  .040     1.6    0.0    5.99   269.7      .6
  9   0.0    278.4   12621    25.6 0.000     0.0    0.0    6.12   277.6      .6
 10   0.0    427.2   16574    53.4 0.000     0.0    0.0    8.66   335.8     1.1
 11   0.0     24.3     370     1.1  .070     0.0      I       R       R       R
 12   0.0    673.8     233      .1  .120     0.0      I       R       R       R
 13   0.0    656.0   32442   179.5  .025     2.8    0.0    5.85   289.4     1.6
 14   0.0    635.4   34134    47.7  .055     5.7    0.0    6.15   330.3      .5
 15   0.0    542.8   29102    72.7  .035     3.2    0.0    5.90   316.4      .8
 16   0.0    414.5   17274   224.8  .060     5.0    0.0    4.93   205.4     2.7
 17   0.0    155.5    2063   632.1  .060     3.4    0.0    2.77    36.8    11.3
 18   0.0     95.5     915   266.8 0.000     0.0    0.0    3.41    32.7     9.5
 19   0.0     60.7     833    93.0  .065     1.3    0.0    3.01    41.4     4.6
 20   0.0     33.0     533    43.8 0.000     0.0    0.0    3.77    60.8     5.0
 21   0.0     24.6     446    15.3 0.000     0.0    0.0   11.23   203.8     7.0
 22   0.0     27.1     322     1.7  .080     0.0      I       R       R       R
 23   0.0    582.2     127      .3  .060     0.0      I       R       R       R

CYCLE COMPOSITE    HC       9.840    GRAM/BHP HR
                   CO     218.548    GRAM/BHP HR
                   NO2      3.264    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .720      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-21-72 RUN 2   ENG. 2-3, PER MAN. SPECS.,   CARB. JETS .075 RODS .038
-------------------------------------------------------------------------------
                DYNA.        MAN. FUEL    A/F             DRY CONCENTRATION
MODE SPEED      LOAD   HP  VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2     NO
-------------------------------------------------------------------------------
   1   600       0.0    0  18.3   3.8   14.4       0  2487    .770   13.33    37
   2  1200       4.5    1  19.7   6.8   15.2       0   750    .420   14.31    66
   3  1200      18.0    4  19.2   7.8   15.0       0   722    .490   14.31    88
   4  1200      41.0    9  18.1   8.5   14.9       0  1822    .350   14.66   420
   5  1200      57.0   13  17.3  10.0   14.8       0  1923    .420   14.66   560
   6  1200     113.0   26  12.4  15.0   14.8       0  2068    .420   14.79  1650
   7  1200     170.0   39   7.2  25.5   13.6       0  2390   2.920   13.48   713
   8  1200     185.0   42   5.1  22.7   13.6       0  2275   2.780   13.63   875
   9  1200     208.0   48   3.3  24.5   13.6       0  2219   2.870   13.63   975
  10  1200     226.0   52    .3  32.5   12.1       0  3080   6.640   10.89   575
  11   600       0.0    0  19.0   3.8   14.8       0  1995    .930   14.18    45
  12  1200       0.0    0  22.5   4.0   16.3       0 46413    .640    7.94     8
  13  2300     258.0  113    .6  66.5   11.7       0  3240   7.340    9.64   710
  14  2300     237.0  104   3.0  53.3   12.9       0  2531   4.540   11.72   830
  15  2300     212.0   93   5.2  47.5   13.1       0  2401   4.120   12.09  1025
  16  2300     194.0   85   6.3  44.5   13.2       0  2353   3.660   12.34  1050
  17  2300     129.0   56  11.7  29.4   14.8       0  1616    .470   14.05  2700
  18  2300      65.0   28  16.8  19.5   14.6       0  1649    .810   14.05  1687
  19  2300      46.0   20  18.5  16.4   14.7       0  1675    .610   14.05   975
  20  2300      21.0    9  21.6  12.4   18.0       0   766    .440   14.18   330
  21  2300       5.0    2  22.3  10.2   14.8       0   629    .470   14.18   127
  22   600       0.0    0  18.3   3.5   15.3       0  1720    .490   13.33    45
  23  2300       0.0    0  24.5   3.8   17.1       0 41937    .390    7.75     7
-------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.     HC      CO     NO2
-------------------------------------------------------------------------------
   1   0.0   24.9      187     1.5  .070      0.0      I       R       R       R
   2   0.0   15.6      177     4.6  .060       .1    0.0   15.20   171.9     4.4
   3   0.0   17.2      235     6.9  .060       .2    0.0    4.18    57.3     1.7
   4   0.0   46.2      179    35.4  .050       .5    0.0    4.94    19.2     3.8
   5   0.0   57.1      252    55.2  .030       .4    0.0    4.39    19.3     4.2
   6   0.0   91.2      374   241.8  .060      1.5    0.0    3.53    14.5     9.4
   7   0.0  166.1     4100   164.4 0.000      0.0    0.0    4.28   105.6     4.2
   8   0.0  140.8     3475   179.8  .040      1.7    0.0    3.33    82.2     4.3
   9   0.0  147.5     3853   215.1 0.000      0.0    0.0    3.10    81.1     4.5
  10   0.0  254.5    11085   157.8 0.000      0.0    0.0    4.93   214.7     3.1
  11   0.0   22.5      212     1.7  .070      0.0      I       R       R       R
  12   0.0  636.9      177      .4  .120      0.0      I       R       R       R
  13   0.0  564.8    25846   410.9  .025      2.8    0.0    5.00   228.8     3.6
  14   0.0  370.5    13427   403.4  .055      5.7    0.0    3.57   129.4     3.9
  15   0.0  314.4    10901   445.7  .035      3.2    0.0    3.39   117.4     4.8
  16   0.0  292.6     9192   433.4  .060      5.1    0.0    3.44   108.2     5.1
  17   0.0  146.8      862   814.2  .060      3.4    0.0    2.60    15.3    14.4
  18   0.0   97.1      963   329.7 0.000      0.0    0.0    3.41    33.8    11.6
  19   0.0   84.0      618   162.4  .065      1.3    0.0    4.17    30.7     8.1
  20   0.0   29.3      340    41.9 0.000      0.0    0.0    3.19    37.0     4.6
  21   0.0   19.8      299    13.3 0.000      0.0    0.0    9.03   136.3     6.1
  22   0.0   19.5      112     1.7  .080      0.0      I       R       R       R
  23   0.0  586.1      110      .3  .060      0.0      I       R       R       R

CYCLE COMPOSITE     HC       8.129    GRAM/BHP HR
                    CO     103.020    GRAM/BHP HR
                    NO2      6.146    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .642      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
    6-21-72 RUN 1         ENG. 2-3, PER MAN. SPECS.,   CARB. JETS .068 RODS .038
---------------------------------------------------------------------------------------
                 DYNA.         MAN.  FUEL     A/F                   DRY CONCENTRATION
MODE SPEED       LOAD     HP   VAC.  LB/HR    RATIO    ALDE.      HC        CO      CO2      NO
---------------------------------------------------------------------------------------
   1   600        0.0      0   17.0    3.5    16.3        0     6045      .440    12.47      28
   2  1200        4.3      1   18.8    6.6    17.2        0      456      .100    13.18      46
   3  1200       17.0      4   18.5    7.3    17.3        0      572      .130    12.34      68
   4  1200       39.0      9   15.1    9.3    18.8        0     1232      .130    12.22      71
   5  1200       54.0     12   12.8   10.8    18.5        0     1237      .130    13.33      76
   6  1200      108.0     25    6.6   17.0    17.3        0      557      .130    13.48     315
   7  1200      162.0     37    2.3   21.4    17.1        0      575      .130    13.63     770
   8  1200      177.0     40    1.4   22.3    16.7        0      599      .150    13.91    1150
   9  1200      199.0     45     .8   23.8    16.1        0      750      .180    14.53    1675
  10  1200      216.0     49     .3   30.5    13.3        0     2435     4.790    12.47     763
  11   600        0.0      0   18.0    3.4    14.9        0     3433      .930    14.66      44
  12  1200        0.0      0   22.9    3.8    16.0        0    61553      .440     7.18      10
  13  2300      250.0    109     .6   62.8    12.4        0     2825     5.900    10.66     900
  14  2300      230.0    101    2.4   46.7    14.8        0     1305      .810    13.77    2600
  15  2300      205.0     90    3.0   42.5    16.0        0      404      .180    13.18    2300
  16  2300      188.0     82    3.9   40.7    16.0        0      416      .210    13.18    2175
  17  2300      125.0     55    7.3   32.4    17.3        0      187      .150    12.22     975
  18  2300       63.0     28   11.3   23.0    19.7        0      413      .180    10.66     145
  19  2300       45.0     20   14.6   18.5    19.8        0      572      .180    10.66     147
  20  2300       20.0      9   17.9   13.6    19.4        0      771      .150    10.78      80
  21  2300        5.0      2   19.8   11.3    20.0        0     4288      .210     9.03      62
  22   600        0.0      0   17.0    3.3    16.3        0     4670      .390    11.72      54
  23  2300        0.0      0   24.7    3.1    18.0        0    47167      .350     6.13       5
---------------------------------------------------------------------------------------
           CALCULATED GRAM/HR           WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2    FAC.       HP   ALDE.      HC       CO      NO2
---------------------------------------------------------------------------------------
   1   0.0    71.0      104      1.1   .070       0.0      I        R        R        R
   2   0.0    10.2       45      3.4   .060        .1    0.0    10.42     46.2      3.5
   3   0.0    15.1       69      5.9   .060        .2    0.0     3.89     17.9      1.5
   4   0.0    41.7       89      8.0   .050        .4    0.0     4.68     10.0       .9
   5   0.0    44.6       95      9.1   .030        .4    0.0     3.62      7.7       .7
   6   0.0    31.4      148     59.0   .060       1.5    0.0     1.27      6.0      2.4
   7   0.0    40.4      184    179.6  0.000       0.0    0.0     1.09      5.0      4.9
   8   0.0    42.9      217    273.5   .040       1.6    0.0     1.06      5.4      6.8
   9   0.0    54.7      265    406.1  0.000       0.0    0.0     1.20      5.8      8.9
  10   0.0   192.5     7648    200.2  0.000       0.0    0.0     3.90    155.0      4.1
  11   0.0    33.2      182      1.4   .070       0.0      I        R        R        R
  12   0.0   770.2      111       .4   .120       0.0      I        R        R        R
  13   0.0   477.8    20157    505.4   .025       2.7    0.0     4.36    184.1      4.6
  14   0.0   187.9     2356   1243.0   .055       5.5    0.0     1.87     23.4     12.3
  15   0.0    58.2      523   1098.5   .035       3.1    0.0      .65      5.8     12.2
  16   0.0    57.2      583    992.5   .060       4.9    0.0      .69      7.1     12.1
  17   0.0    22.2      359    384.0   .060       3.3    0.0      .41      6.6      7.0
  18   0.0    39.6      349     46.2  0.000       0.0    0.0     1.43     12.6      1.7
  19   0.0    44.1      280     37.7   .065       1.3    0.0     2.24     14.2      1.9
  20   0.0    43.2      170     14.9  0.000       0.0    0.0     4.93     19.4      1.7
  21   0.0   227.3      225     10.9  0.000       0.0    0.0   103.81    102.7      5.0
  22   0.0    55.6       94      2.1   .080       0.0      I        R        R        R
  23   0.0   592.4       89       .2   .060       0.0      I        R        R        R

CYCLE COMPOSITE     HC       7.171     GRAM/BHP HR
                    CO      32.014     GRAM/BHP HR
                    NO2      8.779     GRAM/BHP HR
                    ALDE     0.000     GRAM/BHP HR
                    BSFC      .642       LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-20-72 RUN 2   ENG. 2-3, PER MAN. SPECS.,   CARB. JETS .064 RODS .038
-----------------------------------------------------------------------------------
               DYNA.         MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR  RATIO   ALDE.     HC        CO       CO2       NO
-----------------------------------------------------------------------------------
   1   600      0.0     0   17.0   2.8   16.4       0   6473      .210     12.34      28
   2  1200      4.0     1   15.3   7.3   23.7       0  24387      .310      6.21       3
   3  1200     16.0     4   11.0   9.6   23.8       0  62888      .180      2.26       1
   4  1200     36.0     8    7.0  13.6   21.4       0   3137      .210      9.64      20
   5  1200     50.0    11    5.5  15.5   20.4       0    670      .150     10.55      38
   6  1200      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
   7  1200      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
   8  1200      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
   9  1200      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  10  1200      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  11   600      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  12  1200      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  13  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  14  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  15  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  16  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  17  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  18  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  19  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  20  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  21  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  22   600      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
  23  2300      0.0     0    0.0   0.0    0.0       0      0     0.000      0.00       0
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.   BRAKE  SPECIFIC GRAM/BHP-HR
MODE ALDE.       HC       CO    NO2  FAC.       HP   ALDE.       HC       CO     NO2
-----------------------------------------------------------------------------------
   1   0.0     62.3       41     .9  .070      0.0       I        R        R       R
   2   0.0    901.4      231     .4  .060       .1     0.0   986.27    253.2      .4
   3   0.0   3137.3      181     .2  .060       .2     0.0   858.19     49.6      .1
   4   0.0    190.4      257    4.0  .050       .4     0.0    23.15     31.3      .5
   5   0.0     43.8      198    8.2  .030       .3     0.0     3.83     17.3      .7
   6   0.0      0.0        0    0.0  .060      0.0     0.0     0.00      0.0     0.0
   7   0.0      0.0        0    0.0 0.000      0.0     0.0     0.00      0.0     0.0
   8   0.0      0.0        0    0.0  .040      0.0     0.0     0.00      0.0     0.0
   9   0.0      0.0        0    0.0 0.000      0.0     0.0     0.00      0.0     0.0
  10   0.0      0.0        0    0.0 0.000      0.0     0.0     0.00      0.0     0.0
  11   0.0      0.0        0    0.0  .070      0.0     0.0     0.00      0.0     0.0
  12   0.0      0.0        0    0.0  .120      0.0     0.0     0.00      0.0     0.0
  13   0.0      0.0        0    0.0  .025      0.0     0.0     0.00      0.0     0.0
  14   0.0      0.0        0    0.0  .055      0.0     0.0     0.00      0.0     0.0
  15   0.0      0.0        0    0.0  .035      0.0     0.0     0.00      0.0     0.0
  16   0.0      0.0        0    0.0  .060      0.0     0.0     0.00      0.0     0.0
  17   0.0      0.0        0    0.0  .060      0.0     0.0     0.00      0.0     0.0
  18   0.0      0.0        0    0.0 0.000      0.0     0.0     0.00      0.0     0.0
  19   0.0      0.0        0    0.0  .065      0.0     0.0     0.00      0.0     0.0
  20   0.0      0.0        0    0.0 0.000      0.0     0.0     0.00      0.0     0.0
  21   0.0      0.0        0    0.0 0.000      0.0     0.0     0.00      0.0     0.0
  22   0.0      0.0        0    0.0  .080      0.0     0.0     0.00      0.0     0.0
  23   0.0      0.0        0    0.0  .060      0.0     0.0     0.00      0.0     0.0

CYCLE COMPOSITE     HC     250.458     GRAM/BHP HR
                    CO      45.165     GRAM/BHP HR
                    NO2       .534     GRAM/BHP HR
                    ALDE     0.000     GRAM/BHP HR
                    BSFC     2.290       LB/BHP HR
```

ENGINE 2-3

EFFECT OF AIR-FUEL RATIO ON EMISSIONS

GRAPHED RESULTS

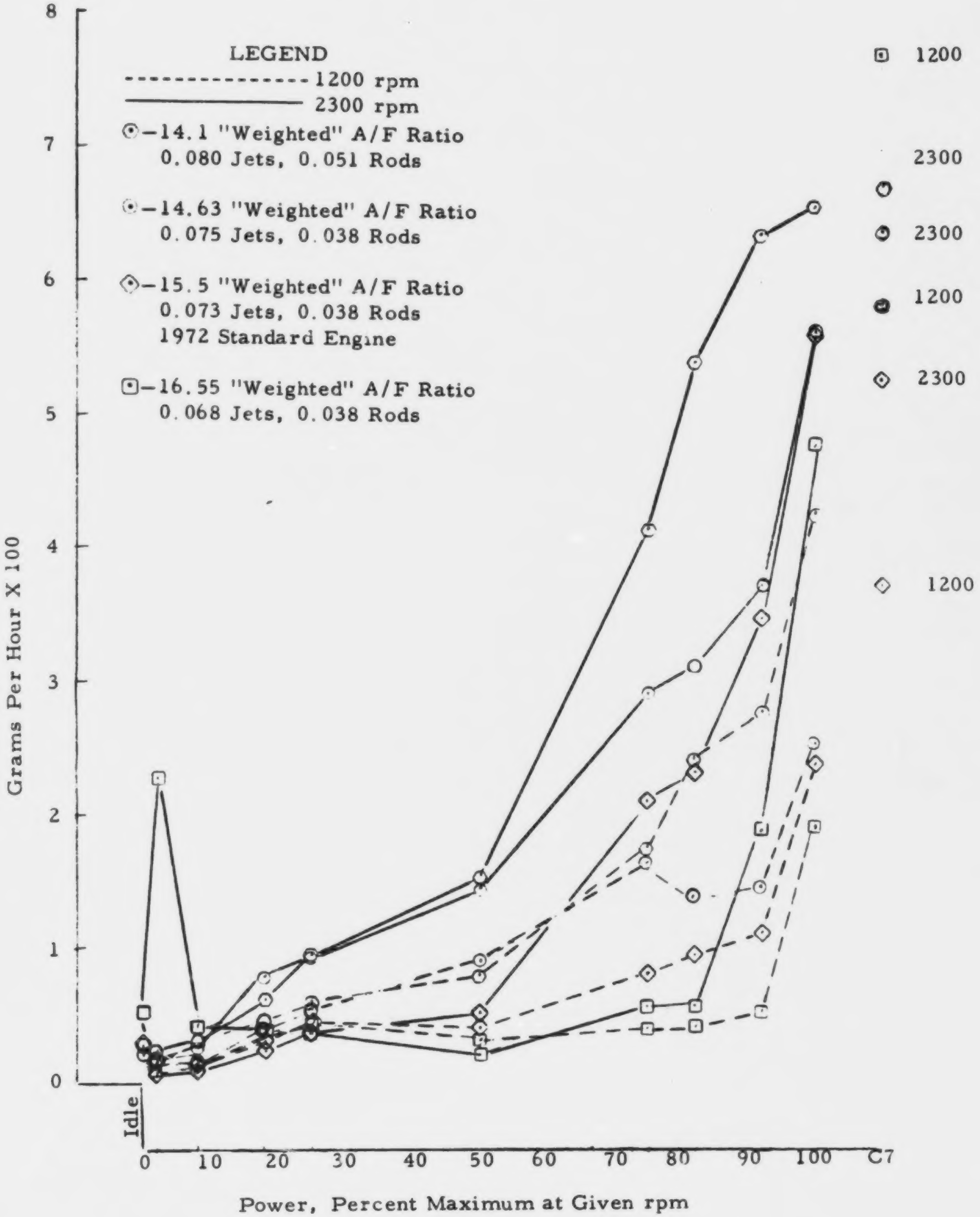


FIGURE I-1. EFFECT OF POWER ON HC EMISSION RATE
ENGINE 2-3, 23 MODE TEST

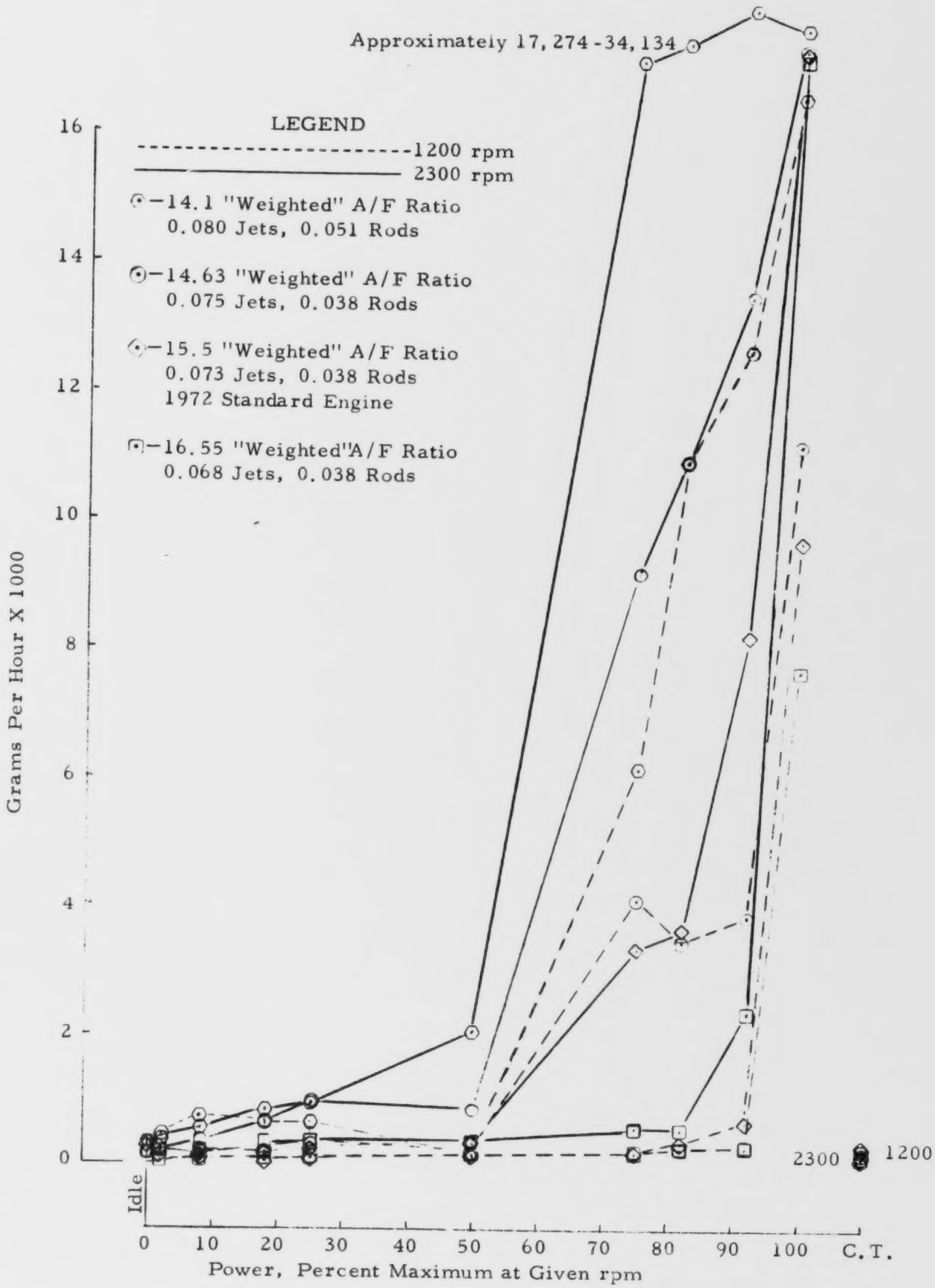


FIGURE I-2. EFFECT OF POWER ON CO EMISSION RATE
ENGINE 2-3, 23 MODE TEST

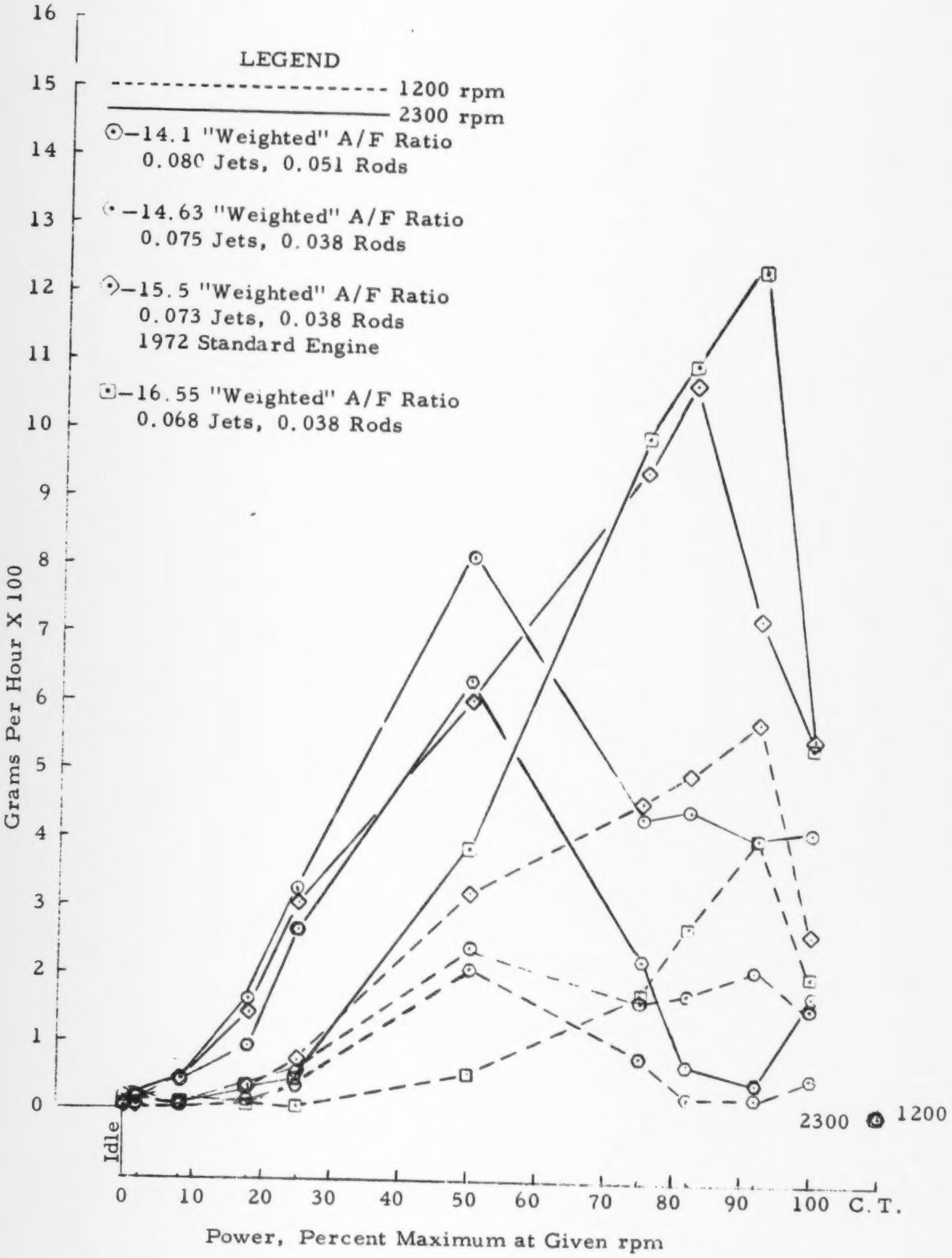


FIGURE I-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE ENGINE 2-3, 23 MODE TEST

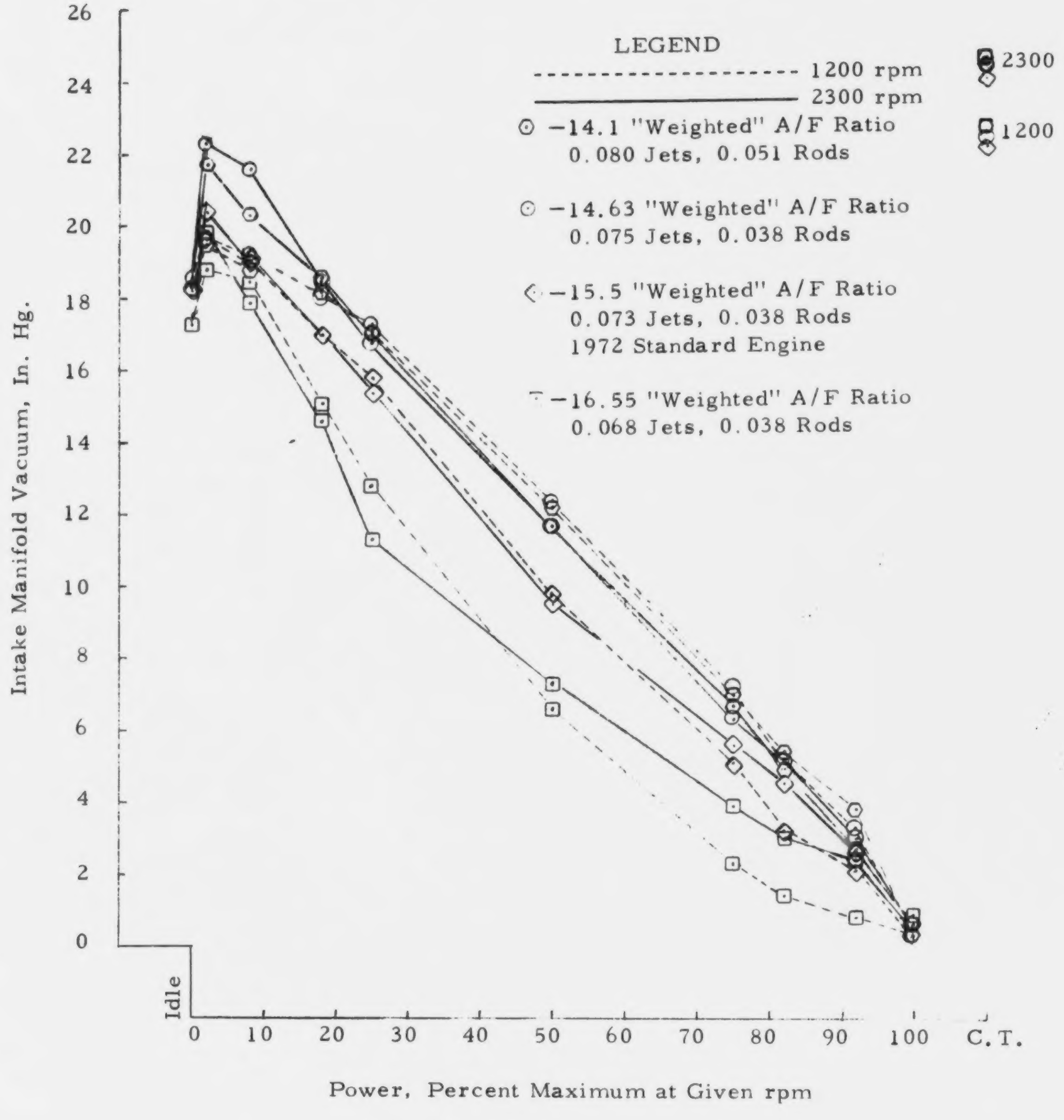


FIGURE I-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 2-3, 23-MODE TEST

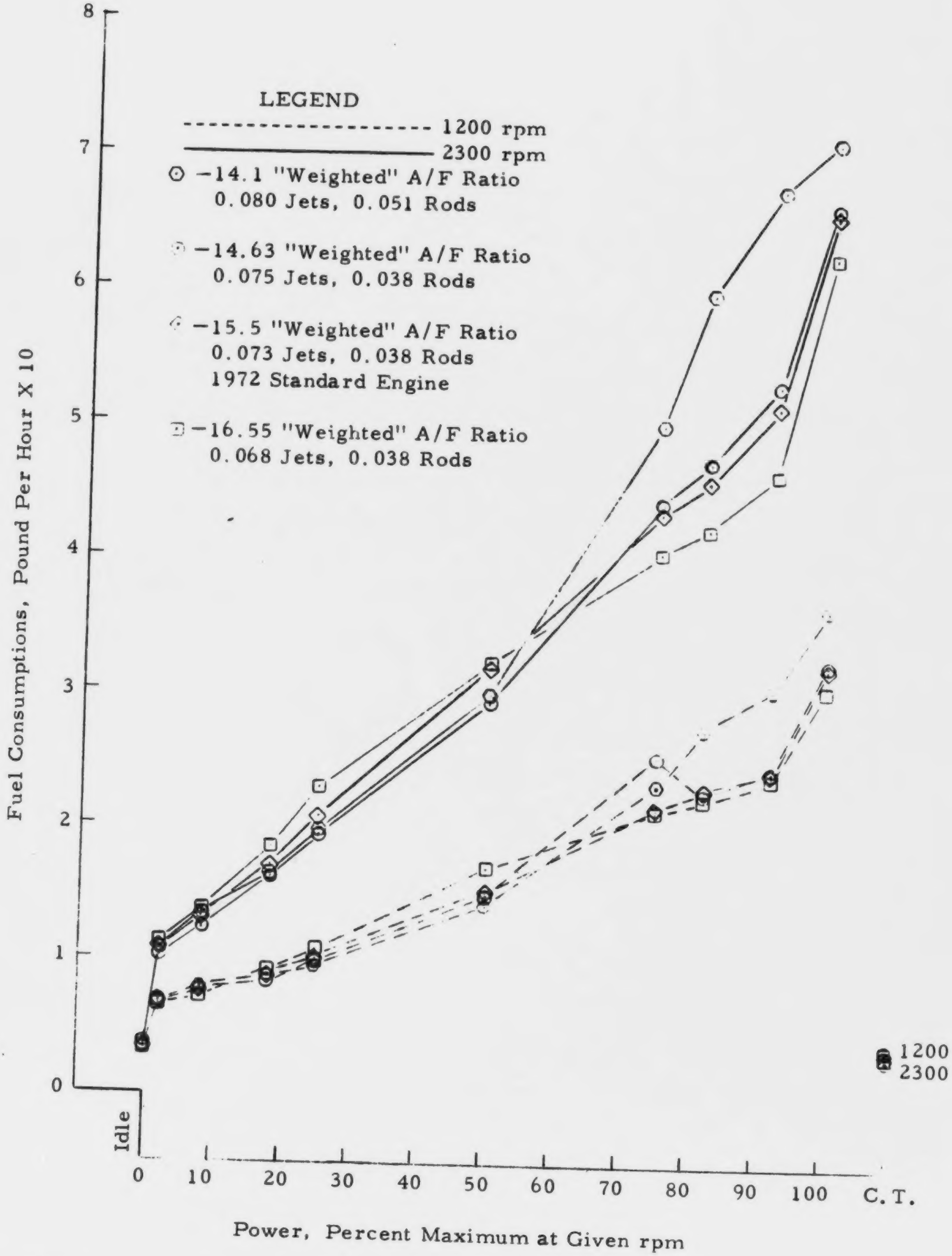


FIGURE I-5. FUEL CONSUMPTION AS A FUNCTION OF POWER
ENGINE 2-3, 23-MODE TEST

APPENDIX J

ENGINE 2-3

EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 2-3

EFFECT OF EXHAUST MANIFOLD AIR INJECTION

TABULAR DATA

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
   6-23-72 RUN 2   ENG. 2-3,  1972 VERSION,  25 BTDC  W/AIR INJECTION
------------------------------------------------------------------------------------------
               DYNA.         MAN. FUEL     A/F                 DRY CONCENTRATION
MODE SPEED     LOAD     HP   VAC. LB/HR   RATIO     ALDE.     HC        CO       CO2     NO
------------------------------------------------------------------------------------------
   1   600      0.0      0   21.0   5.5    24.1         0    714      .100      8.75     49
   2  1200      5.0      1   20.6   5.8    23.9         0    693      .130      8.84     61
   3  1200     20.0      6   20.0   7.0    23.4         0    705      .130      9.03     81
   4  1200     46.0     11   18.0   9.4    21.9         0   1450      .100      9.64    620
   5  1200     64.0     15   15.8  10.6    20.7         0   1778      .100     10.43   1462
   6  1200    128.0     29    9.7  14.8    20.0         0   1759      .100     10.66   2037
   7  1200    192.0     44    5.4  21.0    17.6         0   2038      .150     12.47   2950
   8  1200    210.0     48    4.3  22.3    17.4         0   1956      .250     12.47   3000
   9  1200    236.0     54    1.9  24.4    17.0         0   1903      .440     12.47   3000
  10  1200    256.0     58     .3  33.2    13.9         0   3649     5.400      9.78   1125
  11   600      0.0      0   21.2   5.8    21.3         0    494     1.700      8.93     61
  12  1200      0.0      0   21.0   5.8    21.6         0    713     1.700      8.75     52
  13  2300    262.0    115     .6  64.2    12.9         0   3370     5.900      9.50   1262
  14  2300    241.0    106    2.3  49.9    14.6         0   1984     2.360     12.09   1862
  15  2300    215.0     94    4.3  42.4    15.7         0    936     1.050     12.71   2800
  16  2300    197.0     86    5.3  40.5    16.1         0    808      .810     12.47   2750
  17  2300    131.0     57    9.7  28.2    19.2         0   1022      .150     11.13   3050
  18  2300     66.0     29   15.6  20.5    20.9         0    996      .150     10.09   2025
  19  2300     47.0     21   17.5  16.6    21.9         0    840      .150      9.64   1200
  20  2300     21.0      9   19.8  13.0    23.9         0    973      .130      8.68    340
  21  2300      5.0      2   21.4   9.9    22.7         0   4555      .130     10.43    100
  22   600      0.0      0   20.5   3.8    22.8         0    710      .130      9.93     58
  23  2300      0.0      0   23.7   5.5    28.4         0  47498      .210      2.11      3
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.        HP   ALDE.     HC       CO      NO2
------------------------------------------------------------------------------------------
   1   0.0    20.0       56     4.6  .070      0.0      I        R        R        R
   2   0.0    20.2       76     5.9  .060       .1    0.0    17.66     66.9      5.2
   3   0.0    24.3       90     9.3  .060       .3    0.0     5.31     19.8      2.0
   4   0.0    62.5       87    88.8  .050       .5    0.0     5.95      8.3      8.4
   5   0.0    79.8       91   218.0  .030       .4    0.0     5.46      6.2     14.9
   6   0.0   108.0      124   415.3  .060      1.8    0.0     3.69      4.2     14.2
   7   0.0   151.4      225   727.5 0.000      0.0    0.0     3.45      5.1     16.6
   8   0.0   153.2      396   780.1  .040      1.9    0.0     3.19      8.2     16.3
   9   0.0   160.8      751   841.5 0.000      0.0    0.0     2.98     13.9     15.6
  10   0.0   353.5    10567   361.8 0.000      0.0    0.0     6.04    180.7      6.2
  11   0.0    12.2      846     5.0  .070      0.0      I        R        R        R
  12   0.0    17.8      859     4.3  .120      0.0      I        R        R        R
  13   0.0   623.7    22054   775.6  .025      2.9    0.0     5.44    192.2      6.8
  14   0.0   306.6     7366   955.5  .055      5.8    0.0     2.90     69.8      9.1
  15   0.0   129.9     2945  1290.5  .035      3.3    0.0     1.38     31.3     13.7
  16   0.0   111.2     2250  1255.4  .060      5.2    0.0     1.29     26.1     14.6
  17   0.0   114.8      341  1138.0  .060      3.4    0.0     2.00      5.9     19.8
  18   0.0    89.6      272   604.6 0.000      0.0    0.0     3.10      9.4     20.9
  19   0.0    64.0      231   303.8  .065      1.3    0.0     3.11     11.2     14.8
  20   0.0    64.4      174    74.7 0.000      0.0    0.0     7.01     18.9      8.1
  21   0.0   185.7      107    13.5 0.000      0.0    0.0    84.81     48.9      6.2
  22   0.0    12.1       45     3.3  .080      0.0      I        R        R        R
  23   0.0  1676.1      150      .3  .060      0.0      I        R        R        R

CYCLE COMPOSITE      HC      6.743    GRAM/BHP HR
                     CO     53.858    GRAM/BHP HR
                     NO2    13.006    GRAM/BHP HR
                     ALDE    0.000    GRAM/BHP HR
                     BSFC     .613      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
   6-30-72 RUN 1    ENG. 2-3, 1972 VERSION,  TIMING 16 BTDC W/AIR INJECTION
-------------------------------------------------------------------------------
                 DYNA.          MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED       LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC      CO      CO2      NO
-------------------------------------------------------------------------------
  1    600       0.0      0   19.0    3.0    16.0        0   8996    .640   12.82     39
  2   1200       6.0      1   20.8    5.9    16.0        0   3674    .350   13.77     64
  3   1200      20.0      5   19.1    7.4    16.3        0   1073    .180   13.77    166
  4   1200      45.0     10   18.1    8.6    16.1        0   2164    .130   14.05    900
  5   1200      63.0     14   16.5    9.9    16.2        0   2423    .100   13.63   1750
  6   1200     126.0     24   10.5   14.9    16.5        0   2248    .100   13.33   3300
  7   1200     189.0     43    5.5   20.8    15.4        0   2552    .350   14.18   3150
  8   1200     207.0     47    3.8   22.2    15.3        0   2444    .700   14.31   3350
  9   1200     232.0     53    1.8   24.1    15.2        0   2526    .700   13.41   3200
 10   1200     252.0     58     .2   31.9    12.9        0   4127   5.560   11.13   1475
 11    600       0.0      0   19.5    2.9    14.7        0   5016   1.660   13.48     54
 12   1200       0.0      0   23.5    2.7    16.5        0  58739    .440    6.91      9
 13   2300     260.0    114     .4   63.2    12.7        0   3723   5.400   10.78   1550
 14   2300     239.0    105    2.8   49.2    14.4        0   2337   1.440   13.18   2650
 15   2300     213.0     93    4.8   45.0    14.4        0   2278   2.980   12.44   3250
 16   2300     195.0     85    6.1   42.2    14.4        0   2307   2.020   13.06   3300
 17   2300     130.0     57   10.5   30.1    16.3        0   1039    .160   14.18   5150
 18   2300      65.0     28   16.0   19.5    16.4        0    896    .160   14.06   3250
 19   2300      47.0     21   17.9   16.1    16.5        0    653    .160   14.18   1838
 20   2300      21.0      9   19.6   13.4    16.6        0    404    .150   14.18    288
 21   2300       5.0      2   21.2   11.0    16.6        0    337    .150   14.18    325
 22    600       0.0      0   19.0    2.8    16.3        0   4803    .580   14.48    625
 23   2300       0.0      0   25.2    2.9    20.6        0  49169    .350    4.64      3
-------------------------------------------------------------------------------
            CALCULATED GRAM/HR            WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO      NO2   FAC.        HP   ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------
  1    0.0     85.3      123      1.2   .070       0.0      I        R        R       R
  2    0.0     67.9      131      3.9   .060        .1     0.0    49.51     95.3     2.9
  3    0.0     25.6       87     13.2   .060        .3     0.0     5.60     19.0     2.4
  4    0.0     58.6       71     81.0   .050        .5     0.0     5.70      6.9     7.9
  5    0.0     77.4       65    186.7   .030        .4     0.0     5.41      4.5    13.0
  6    0.0    111.3      100    542.3   .060       1.7     0.0     3.87      3.5    18.8
  7    0.0    162.9      451    667.4  0.000       0.0     0.0     3.77     10.4    15.5
  8    0.0    161.6      933    734.2   .040       1.9     0.0     3.42     19.7    15.5
  9    0.0    185.8     1040    781.4  0.000       0.0     0.0     3.50     19.6    14.7
 10    0.0    349.2     9502    414.3  0.000       0.0     0.0     6.06    165.0     7.2
 11    0.0     42.2      282      1.5   .070       0.0      I        R        R       R
 12    0.0    544.0       82       .3   .120       0.0      I        R        R       R
 13    0.0    625.8    20036    865.1   .025       2.8     0.0     5.50    176.0     7.6
 14    0.0    339.6     5696   1278.8   .055       5.8     0.0     3.25     54.4    12.2
 15    0.0    304.9     5625   1444.4   .035       3.3     0.0     3.27     60.3    15.5
 16    0.0    288.5     5101   1369.7   .060       5.1     0.0     3.38     54.7    16.0
 17    0.0    105.4      369   1733.9   .060       3.4     0.0     1.85      6.5    30.5
 18    0.0     59.6      241    716.0  0.000       0.0     0.0     2.09      8.5    25.2
 19    0.0     35.5      198    331.9   .065       1.3     0.0     1.73      9.6    16.1
 20    0.0     18.4      138    118.9  0.000       0.0     0.0     2.00     15.0    12.9
 21    0.0     12.6      113     40.3  0.000       0.0     0.0     5.75     51.7    18.4
 22    0.0     42.0      102     18.1   .080       0.0      I        R        R       R
 23    0.0    652.9       94       .4   .060       0.0      I        R        R       R

CYCLE COMPOSITE     HC       7.938      GRAM/BHP HR
                    CO      54.975      GRAM/BHP HR
                    NO2     15.922      GRAM/BHP HR
                    ALDE     0.000      GRAM/BHP HR
                    BSFC      .588        LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-23-72 RUN 1          ENG. 2-3,  1972 VERSION,  WITH FACT. AIR INJECTION
----------------------------------------------------------------------------------------------
                  DYNA.         MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED        LOAD    HP    VAC. LB/HR    RATIO    ALDE.     HC       CO       CO2     NO
----------------------------------------------------------------------------------------------
   1   680         0.0     0    18.0   3.8    22.6
   2  1200         4.0     1    19.6   7.0    23.4        0    1628     .100      9.14     25
   3  1200        18.0     4    18.6   8.5    22.6        0     433     .020      8.93     44
   4  1200        40.0     9    17.5   9.3    22.2        0     651     .020      9.25    125
   5  1200        55.0    13    16.7  10.2    21.5        0    1022     .020      9.37    345
   6  1200       110.0    25    10.3  14.9    20.0        0    1156     .020      9.78    430
   7  1200       165.0    38     5.5  21.0    18.1        0    1111     .020     10.78    875
   8  1200       180.0    41     4.2  22.3    17.7        0     999     .070     11.84   1412
   9  1200       202.0    46     2.3  23.6    17.1        0     947     .130     12.22   1537
  10  1200       220.0    50      .3  32.2    13.9        0     958     .150     12.22   1850
  11   680         0.0     0    18.5   3.5    21.4        0    1596    4.120     11.01    835
  12  1200         0.0     0    22.7   3.3    28.2        0     723     .210      9.64     37
  13  2300       246.0   108      .6  66.1    12.9        0   39097     .130      2.99      3
  14  2300       226.0    99     3.1  48.3    15.2        0    2643    5.560     10.55    875
  15  2300       202.0    88     4.8  43.7    15.7        0     532     .810     13.48   2000
  16  2300       185.0    81     5.9  41.9    15.6        0     195     .470     13.48   1850
  17  2300       123.0    54    10.5  28.9    18.9        0     121     .440     13.48   1500
  18  2300        62.0    27    15.5  20.1    20.8        0     343     .150     11.36   1787
  19  2300        44.0    19    17.2  17.5    21.8        0     548     .150     10.25   1188
  20  2300        20.0     9    18.9  14.8    23.2        0     491     .130      9.64    730
  21  2300         5.0     2    21.0  10.7    24.9        0     412     .130      8.43    330
  22   680         0.0     0    18.0   3.5    22.0        0     259     .100      8.48    100
  23  2300         0.0     0    24.5   3.3    32.9        0    1090     .180      9.50     35
                                                          0   58597     .050       .13      2
----------------------------------------------------------------------------------------------
             CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.       HC       CO     NO2     FAC.      HP   ALDE.      HC       CO      NO2
----------------------------------------------------------------------------------------------
   1   0.0      29.8      37      1.5    .070     0.0
   2   0.0      15.3      14      5.2    .060      .1      I        R        R        R
   3   0.0      26.9      17     17.1    .060      .2     0.0    16.73     15.6      5.7
   4   0.0      45.4      18     50.9    .050      .5     0.0     6.54      4.1      4.2
   5   0.0      53.9      19     66.6    .030      .4     0.0     4.97      2.0      5.6
   6   0.0      68.8      25    179.9    .060     1.5     0.0     4.29      1.5      5.3
   7   0.0      79.2     112    371.9   0.000     0.0     0.0     2.74      1.0      7.2
   8   0.0      77.0     213    414.8    .040     1.6     0.0     2.10      3.0      9.9
   9   0.0      82.3     260    527.4   0.000     0.0     0.0     1.87      5.2     10.1
  10   0.0     152.5    7950    264.8   0.000     0.0     0.0     1.78      5.6     11.4
  11   0.0      11.6      68      2.0    .070     0.0     0.0     3.03    158.2      5.3
  12   0.0     832.5      56       .2    .120     0.0      I        R        R        R
  13   0.0     483.9   20565    531.9    .025     2.7      I        R        R        R
  14   0.0      81.3    2499   1014.2    .055     5.4     0.0     4.49    190.9      4.9
  15   0.0      27.6    1347    871.5    .035     3.1     0.0      .82     25.3     10.2
  16   0.0      16.6    1212    679.4    .060     4.9     0.0      .31     15.2      9.9
  17   0.0      38.9     344    673.9    .060     3.2     0.0      .20     15.0      8.4
  18   0.0      47.8     264    343.8   0.000     0.0     0.0      .72      6.4     12.5
  19   0.0      39.7     212    195.9    .065     1.3     0.0     1.76      9.7     12.7
  20   0.0      30.4     194     80.8   0.000     0.0     0.0     2.06     11.0     10.2
  21   0.0      14.6     114     18.7   0.000     0.0     0.0     3.47     22.1      9.2
  22   0.0      17.7      59      1.9    .080     0.0     0.0     6.67     52.0      8.6
  23   0.0    1452.3      25       .1    .060     0.0      I        R        R        R
                                                           I        R        R        R

CYCLE COMPOSITE      HC       9.186    GRAM/BHP HR
                     CO      33.763    GRAM/BHP HR
                     NO2      9.138    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .647      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-26-72 RUN 3      ENG. 2-3, 1972 VERSION, TIMING  4 ATDC W/AIR INJECTION
-------------------------------------------------------------------------------
                DYNA.       MAN. FUEL    A/F                  DRY CONCENTRATION
MODE SPEED      LOAD    HP  VAC. LB/HR  RATIO    ALDE.     HC        CO       CO2     NO
-------------------------------------------------------------------------------
  1    600       0.0     0  16.5   5.2   21.7        0    216      .130      9.78     65
  2   1200       3.0     1  18.8   5.4   22.9        0    144      .130      9.37     81
  3   1200      14.0     3  18.3   8.3   22.7        0    196      .130      9.37     73
  4   1200      31.0     7  16.6   9.2   21.8        0    418      .130      9.93    204
  5   1200      43.0    10  16.2  10.0   21.4        0    438      .130     10.09    245
  6   1200      86.0    20   9.8  15.5   19.4        0    292      .100     11.01    425
  7   1200     129.0    29   5.5  20.5   17.3        0    513      .150     12.34    915
  8   1200     141.0    32   3.4  22.6   17.3        0   1049      .150     12.34   1063
  9   1200     158.0    36   2.7  25.2   16.8        0   2351      .310     12.59   1075
 10   1200     172.0    39    .2  32.2   13.9        0    572     3.010     12.47    555
 11    600       0.0     0  17.2   5.3   20.6        0     92      .130     10.55     88
 12   1200       0.0     0  20.3   6.4   23.9        0   3403      .150      8.54     28
 13   2300     210.0    42    .5  64.7   13.0        0    726     5.140     11.24    505
 14   2300     143.0    85   3.2  48.0   15.1        0     45      .420     14.05   1287
 15   2300     172.0    75   4.7  44.4   15.4        0     19      .150     14.05   1100
 16   2300     158.0    69   6.0  41.6   15.7        0     19      .130     13.77   1000
 17   2300     105.0    46   9.7  29.7   19.3        0     50      .100     11.24    840
 18   2300      53.0    23  15.9  19.3   21.2        0    114      .100     10.25    550
 19   2300      38.0    17  17.2  17.2   22.3        0    120      .100      9.37    350
 20   2300      17.0     7  19.2  14.0   24.1        0     87      .100      8.75    130
 21   2300       4.0     2  21.0  10.7   25.2        0     88      .100      6.43     62
 22    600       0.0     0  16.5   6.0   21.8        0    132      .100      9.78     75
 23   2300       0.0     0  23.2   6.2   51.0        0  26819      .150      1.15      2
-------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2  FAC.       HP  ALDE.       HC        CO     NO2
-------------------------------------------------------------------------------
  1    0.0     5.1       62      5.1  .070      0.0      I        R         R       R
  2    0.0     3.7       68      7.0  .060       .0    0.0     5.41      98.6    10.2
  3    0.0     7.7      104      9.6  .060       .2    0.0     2.42      32.5     3.0
  4    0.0    17.3      108     27.9  .050       .4    0.0     2.44      15.3     3.9
  5    0.0    19.3      116     35.9  .030       .3    0.0     1.97      11.8     3.7
  6    0.0    18.4      127     89.1  .060      1.2    0.0      .94       6.5     4.5
  7    0.0    38.0      225    225.2 0.000      0.0    0.0     1.29       7.6     7.6
  8    0.0    85.3      247    287.1  .040      1.3    0.0     2.65       7.7     8.9
  9    0.0   204.6      545    310.6 0.000      0.0    0.0     5.67      15.1     8.6
 10    0.0    53.7     5716    173.2 0.000      0.0    0.0     1.37     145.4     4.4
 11    0.0     2.1       59      6.6  .070      0.0      I        R         R       R
 12    0.0   109.4       97      3.0  .120      0.0      I        R         R       R
 13    0.0   129.1    18644    298.2  .025      2.3    0.0     1.40     202.7     3.2
 14    0.0     6.7     1276    643.0  .055      4.6    0.0      .08      15.1     7.6
 15    0.0     2.8      430    517.9  .035      2.6    0.0      .04       5.7     6.9
 16    0.0     2.6      356    450.6  .060      4.2    0.0      .04       5.2     6.5
 17    0.0     5.9      240    331.2  .060      2.8    0.0      .13       5.2     7.2
 18    0.0     9.6      171    154.3 0.000      0.0    0.0      .41       7.4     6.6
 19    0.0     4.8      166     95.6  .065      1.1    0.0      .59      10.0     5.7
 20    0.0     6.2      145     30.9 0.000      0.0    0.0      .83      19.5     4.2
 21    0.0     5.0      115     11.7 0.000      0.0    0.0     2.84      65.5     6.7
 22    0.0     3.6       56      6.9  .080      0.0      I        R         R       R
 23    0.0  1894.2      214       .5  .060      0.0      I        R         R       R

CYCLE COMPOSITE      HC        6.646     GRAM/BHP HR
                     CO       32.118     GRAM/BHP HR
                     NO2       6.506     GRAM/BHP HR
                     ALDE      0.000     GRAM/BHP HR
                     BSFC       .811       LB/BHP HR
```

ENGINE 2-3

EFFECT OF EXHAUST MANIFOLD AIR INJECTION

GRAPHED RESULTS

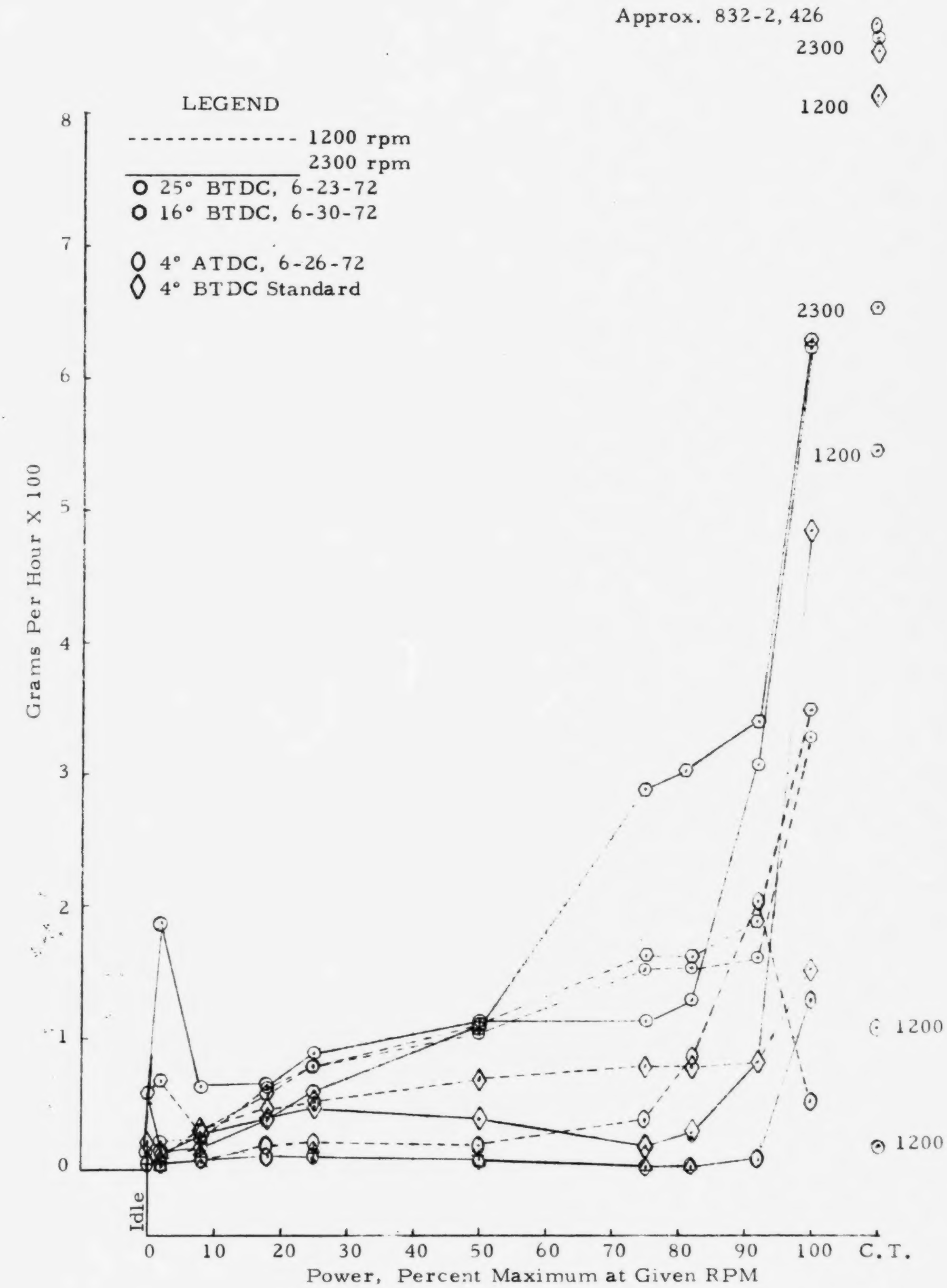


FIGURE J-1. EFFECT OF POWER ON HC EMISSION RATE - AIR INJECTION ENGINE 2-3, 23 MODE TEST

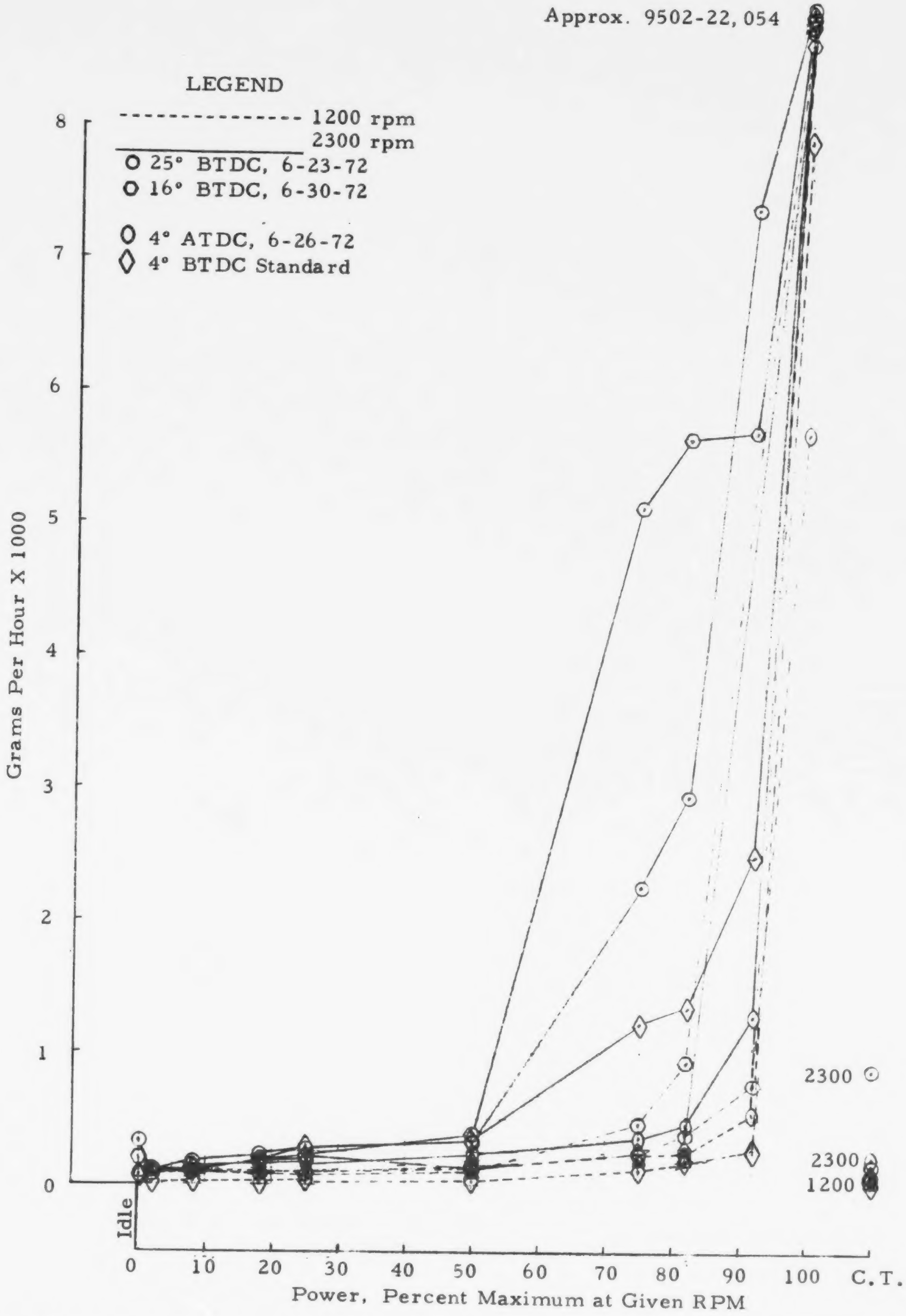


FIGURE J-2. EFFECT OF POWER ON CO EMISSION RATE - AIR INJECTION ENGINE 2-3, 23 MODE TEST

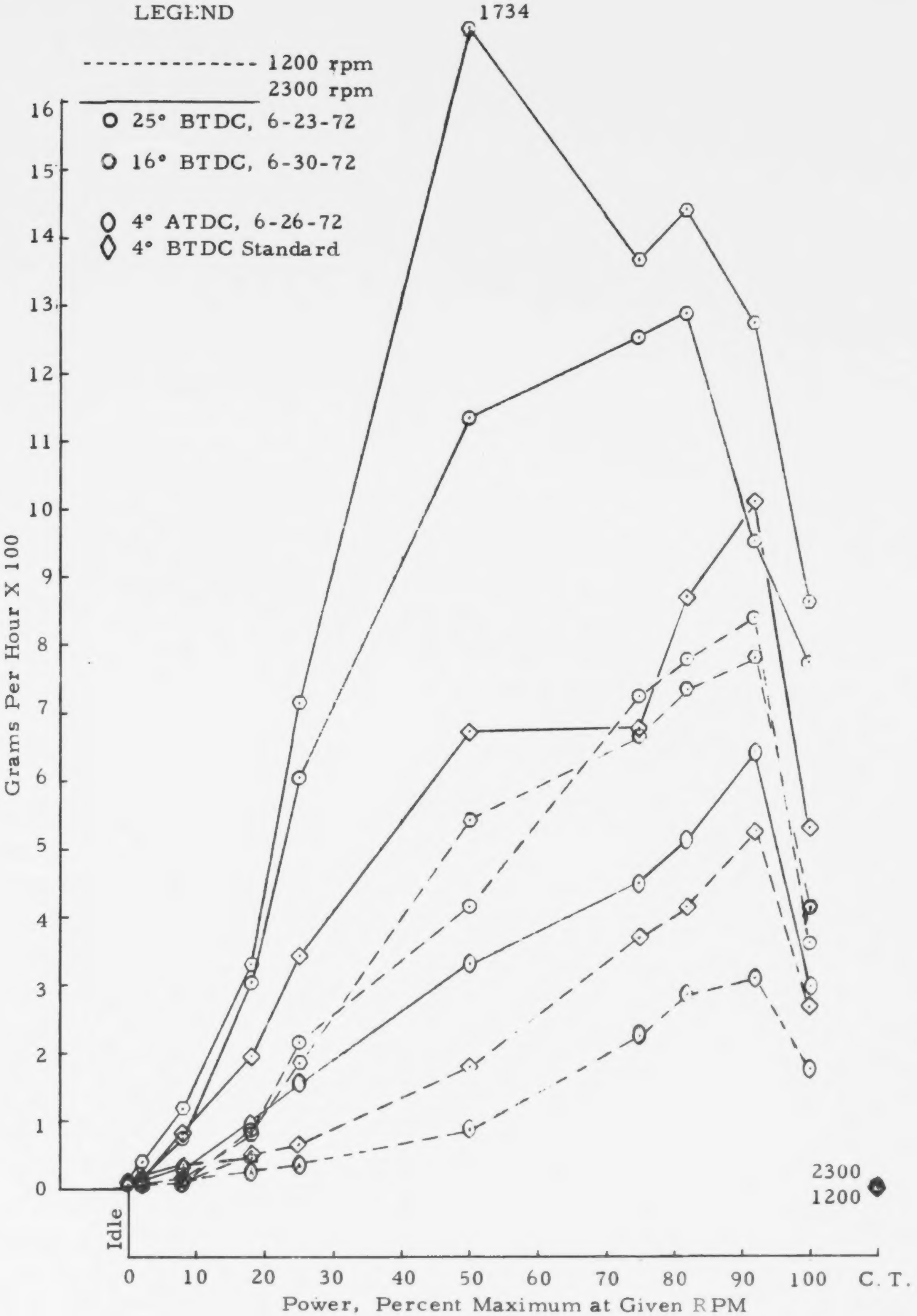


FIGURE J-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE - AIR INJECTION
ENGINE 2-3, 23 MODE TEST

249

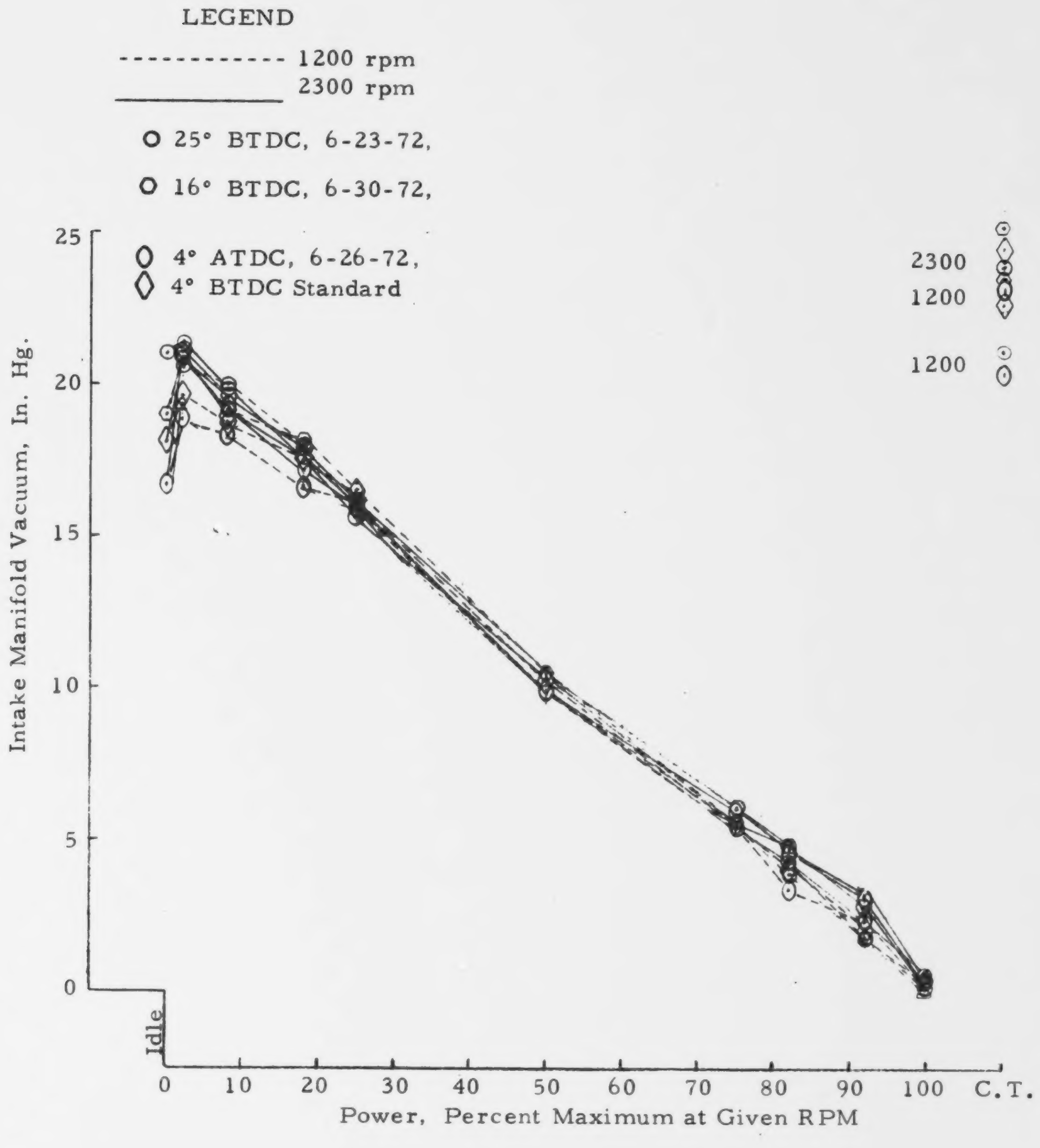


FIGURE J-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 2-3, 23 MODE TEST

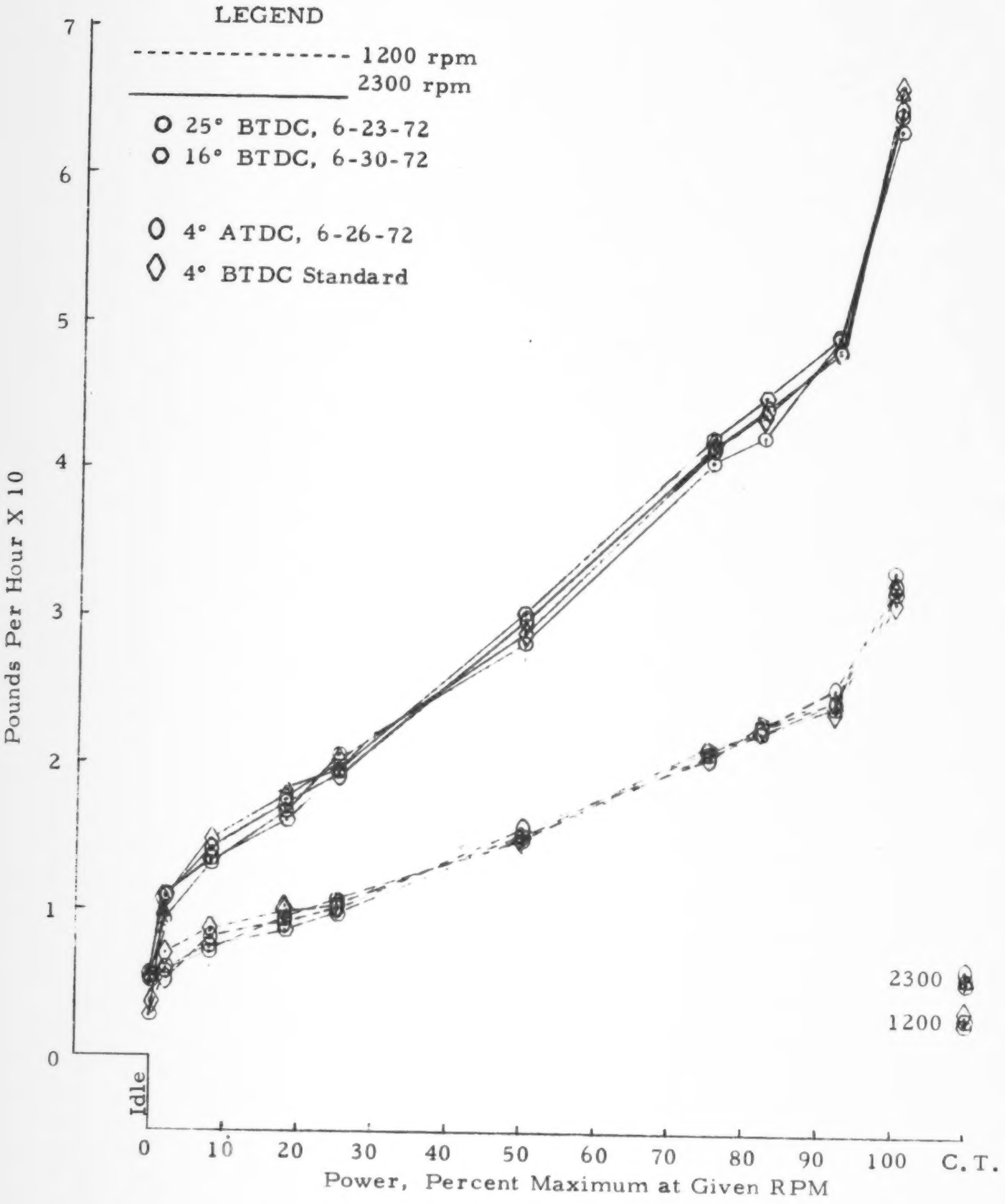


FIGURE J-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 2-3, 23 MODE TEST

APPENDIX K

ENGINE 2-3

EFFECT OF FACTORY EGR ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 2-3

EFFECT OF FACTORY EGR ON EMISSIONS

TABULAR DATA

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-27-72 RUN 3    ENG. 2-3, 1972 VERSION, TIMING 25 BTDC W/EGR
------------------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F                  DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
------------------------------------------------------------------------------------------
  1    600     0.0     0   20.9   5.5    42.7         0    834     .150     4.45      74
  2   1200     5.0     1   18.8   7.0    47.2         0   1920     .150     3.95      41
  3   1200    20.0     5   14.0   8.7    45.8         0   3448     .150     3.35      34
  4   1200    46.0    11   11.3  10.5    47.9         0   3571     .100     3.68      99
  5   1200    64.0    15   10.0  11.5    48.2         0   2383     .100     3.81     122
  6   1200   128.0    29    6.6  14.7    45.0         0    822     .070     4.36     134
  7   1200   192.0    44    3.7  20.5    42.9         0    282     .130     4.45    2650
  8   1200   210.0    48    3.0  22.0    42.9         0    221     .130     4.45    3500
  9   1200   236.0    54    1.4  25.4    40.6         0    816     .310     4.64    3300
 10   1200   256.0    58     .3  31.8    33.5         0   1442    2.250     3.50    1325
 11    600     0.0     0   20.9   5.5    44.2         0    812     .310     4.13      27
 12   1200     0.0     0   21.0   6.0    48.1         0    644     .180     3.95      26
 13   2300   264.0   116     .6  63.8    12.6         0   1405    6.140    10.66    1425
 14   2300   243.0   106    2.5  50.3    13.8         0   1149    3.060    13.06    1725
 15   2300   216.0    95    4.0  44.0    14.3         0   1106    1.940    13.48    2400
 16   2300   198.0    87    4.8  42.2    14.4         0   1130    1.940    13.33    2100
 17   2300   132.0    58    8.1  30.9    15.8         0    724     .210    14.41    1350
 18   2300    66.0    29   13.1  20.4    16.4         0    460     .160    13.48     435
 19   2300    48.0    21   14.2  18.4    16.4         0    461     .160    13.18     245
 20   2300    21.0     9   16.4  15.0    16.3         0   1150     .250    13.44     136
 21   2300     5.0     2   17.6  12.7    16.6         0   3249     .410    12.71      80
 22    600     0.0     0   20.8   5.6    15.3         0    454     .260    14.18      40
 23   2300     0.0     0   23.5   5.8    20.2         0  26053     .580     7.46       9
------------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1   0.0    44.4     161    13.2  .020     0.0       I        R        R        R
  2   0.0   142.1     224    10.2  .060      .1     0.0   124.34    196.2      8.9
  3   0.0   842.3     264    10.0  .060      .3     0.0   164.33     58.8      2.2
  4   0.0   411.1     233    37.7  .050      .5     0.0    39.11     22.1      3.6
  5   0.0   299.7     254    51.1  .030      .4     0.0    20.44     17.4      3.5
  6   0.0   121.5     209    65.6  .060     1.8     0.0     4.16      7.1      2.2
  7   0.0   156.1     524  1256.3 0.000     0.0     0.0     3.56     11.9     40.0
  8   0.0   165.3     563  2489.9  .040     1.9     0.0     3.44     11.7     51.9
  9   0.0   186.8    1434  2508.7 0.000     0.0     0.0     3.46     26.6     46.5
 10   0.0   350.6   11124  1076.7 0.000     0.0     0.0     5.49    140.2     18.4
 11   0.0    44.2     341    13.9  .020     0.0       I        R        R        R
 12   0.0    41.8     236    16.4  .120     0.0       I        R        R        R
 13   0.0   240.4   21165   806.7  .025     2.9     0.0     2.08    183.1      7.0
 14   0.0   161.5    8687   804.9  .055     5.9     0.0     1.52     81.6      7.6
 15   0.0   142.4    5036   981.3  .035     3.3     0.0     1.51     53.2     10.4
 16   0.0   140.6    4876   867.6  .060     5.2     0.0     1.62     56.2     10.0
 17   0.0    69.4     407   429.7  .060     3.5     0.0     1.20      7.0      7.4
 18   0.0    31.0     245    97.5 0.000     0.0     0.0     1.07      8.5      3.4
 19   0.0    28.7     226    61.0  .065     1.4     0.0     1.36     10.8      2.9
 20   0.0    56.5     248    22.2 0.000     0.0     0.0     6.14     27.0      2.4
 21   0.0   140.3     220    11.5 0.000     0.0     0.0    64.06    123.5      5.2
 22   0.0     7.4      99     5.2  .080     0.0       I        R        R        R
 23   0.0   643.9     290      .7  .060     0.0       I        R        R        R

CYCLE COMPOSITE    HC       6.920    GRAM/BHP HR
                   CO      62.334    GRAM/BHP HR
                   NO2     10.827    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .639      LB/BHP HR
```

PROJECT 11-2877-01 CONTROL TECHNOLOGY

6-28-72 RUN 1 ENG. 2-3, 16 BTDC W/EGR, DIST. VAC. FOR SIGNAL

		DYNA.		MAN.	FUEL	A/F		DRY CONCENTRATION			
MODE	SPEED	LOAD	HP	VAC.	LB/HR	RATIO	ALDE.	HC	CO	CO2	NO
1	600	0.0	0	18.5	4.9	15.2	0	6197	.770	12.94	40
2	1200	5.0	1	15.0	8.2	15.9	0	37057	.470	9.25	19
3	1200	20.0	5	13.4	9.0	15.7	0	18653	.440	11.84	48
4	1200	45.0	10	10.4	11.0	15.8	0	7996	.280	12.94	105
5	1200	63.0	14	9.2	12.6	15.7	0	3034	.210	13.77	164
6	1200	125.0	29	6.0	16.5	15.1	0	1873	.280	14.31	375
7	1200	188.0	43	3.7	20.4	15.0	0	2299	.440	14.18	2075
8	1200	205.0	47	3.1	21.7	15.1	0	2270	.390	14.18	2450
9	1200	230.0	53	1.8	23.8	14.9	0	2384	.580	14.05	2950
10	1200	250.0	57	.3	31.8	12.7	0	3865	5.500	11.13	1212
11	600	0.0	0	18.5	5.0	14.2	0	4334	1.870	13.33	71
12	1200	0.0	0	23.1	5.1	15.1	0	61702	.670	7.23	23
13	2300	264.0	116	.5	63.0	12.5	0	3780	6.020	10.66	1350
14	2300	243.0	106	2.9	48.2	14.2	0	2342	1.940	13.48	2300
15	2300	216.0	95	4.2	43.1	14.3	0	2212	2.020	13.33	1737
16	2300	198.0	87	4.9	41.3	14.3	0	2083	1.940	13.33	1350
17	2300	132.0	58	8.1	29.8	14.3	0	2170	2.020	13.33	1325
18	2300	66.0	29	13.0	20.0	15.5	0	1273	.550	13.63	820
19	2300	48.0	21	14.6	15.3	16.2	0	620	.180	13.63	275
20	2300	21.0	9	16.5	14.5	16.2	0	774	.210	13.48	145
21	2300	5.0	2	18.0	16.5	16.2	0	1799	.250	13.18	75
22	600	0.0	0	18.5	4.8	15.7	0	3654	.340	13.06	31
23	2300	0.0	0	24.7	5.0	18.1	0	40805	.420	7.56	9

	CALCULATED GRAM/HR				WT.	WT.	BRAKE SPECIFIC GRAM/BHP-HR			
MODE	ALDE.	HC	CO	NO2	FAC.	HP	ALDE.	HC	CO	NO2
1	0.0	46.1	241	2.1	.070	0.0	I	R	R	R
2	0.0	1026.6	263	1.8	.060	.1	0.0	898.66	230.2	1.5
3	0.0	538.3	257	4.6	.060	.3	0.0	117.80	56.1	1.0
4	0.0	284.6	201	12.4	.050	.5	0.0	27.68	19.6	1.2
5	0.0	121.4	170	21.8	.030	.4	0.0	8.44	11.8	1.5
6	0.0	94.8	286	63.1	.060	1.7	0.0	3.32	10.0	2.2
7	0.0	143.2	554	429.3	0.000	0.0	0.0	3.33	12.9	10.0
8	0.0	151.0	524	541.1	.040	1.9	0.0	3.22	11.2	11.6
9	0.0	173.1	851	711.1	0.000	0.0	0.0	3.29	16.2	13.5
10	0.0	327.7	9418	341.2	0.000	0.0	0.0	5.74	164.9	6.0
11	0.0	62.9	548	3.4	.070	0.0	I	R	R	R
12	0.0	1014.5	223	1.2	.120	0.0	I	R	R	R
13	0.0	633.3	20372	750.9	.025	2.9	0.0	5.48	176.2	6.5
14	0.0	327.2	5473	1066.5	.055	5.9	0.0	3.07	51.4	10.0
15	0.0	277.7	5123	724.3	.035	3.3	0.0	2.94	54.2	7.7
16	0.0	252.1	4743	542.5	.060	5.2	0.0	2.91	54.7	6.3
17	0.0	188.4	3543	382.0	.060	3.5	0.0	3.26	61.3	6.6
18	0.0	80.7	704	172.6	0.000	0.0	0.0	2.79	24.4	6.0
19	0.0	31.0	182	45.7	.065	1.4	0.0	1.48	8.7	2.2
20	0.0	37.0	203	23.0	0.000	0.0	0.0	4.02	22.0	2.5
21	0.0	98.4	278	13.8	0.000	0.0	0.0	45.18	126.8	6.3
22	0.0	57.6	124	1.6	.080	0.0	I	R	R	R
23	0.0	767.3	160	.6	.060	0.0	I	R	R	R

CYCLE COMPOSITE			
	HC	14.054	GRAM/BHP HR
	CO	62.467	GRAM/BHP HR
	NO2	7.008	GRAM/BHP HR
	ALDE	0.000	GRAM/BHP HR
	BSFC	.623	LB/BHP HR

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-27-72 RUN 2       ENG. 2-3, 4 BTDC W/EGR, DIST. VAC. FOR SIGNAL
------------------------------------------------------------------------------------
             DYNA.        MAN. FUEL    A/F                 DRY CONCENTRATION
MODE SPEED   LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC        CO        CO2      NO
------------------------------------------------------------------------------------
  1    600     0.0    0   13.9    8.3   16.8        0 11990      .550     11.36      21
  2   1200     4.0    1   13.4    8.6   17.5        0 11070      .440     11.13      20
  3   1200    17.0    4    9.9   11.1   17.5        0  3348      .310     12.22      34
  4   1200    39.0    9    7.7   13.7   15.3        0   621      .210     13.77      82
  5   1200    54.0   12    6.9   15.0   15.3        0   323      .210     14.05      41
  6   1200   108.0   25    5.2   17.2   15.4        0   368      .180     14.05     340
  7   1200   162.0   37    3.6   19.6   15.3        0   504      .180     14.18    1012
  8   1200   177.0   40    2.7   21.3   15.2        0   589      .490     13.91    1775
  9   1200   199.0   45    1.8   22.7   15.1        0   760      .550     13.91    1887
 10   1200   216.0   49     .3   29.7   12.8        0  1348     5.350     11.13     770
 11    600     0.0    0   14.2    8.2   16.2        0 10923      .670     11.72      25
 12   1200     0.0    0   14.1    8.3   16.4        0 11007      .610     11.48      23
 13   2300   243.0  106     .5   61.7   12.6        0  1213     6.020     10.78     870
 14   2300   221.0   97    2.8   44.3   14.2        0   892     1.980     13.48    1825
 15   2300   199.0   87    3.8   42.4   14.2        0   879     2.020     13.33    1387
 16   2300   182.0   80    4.7   39.1   14.3        0   769     1.800     13.33    1050
 17   2300   122.0   53    7.5   31.5   15.1        0   380      .520     14.05     550
 18   2300    61.0   27   11.5   21.5   16.3        0   109      .130     13.18     245
 19   2300    44.0   19   13.8   18.4   16.3        0   169      .150     13.33      63
 20   2300    19.0    8   15.2   15.5   16.2        0   276      .150     13.48     104
 21   2300     5.0    2   16.6   13.6   16.1        0   865      .210     13.18      65
 22    600     0.0    0   13.9    8.2   16.4        0 10348      .580     11.60      25
 23   2300     0.0    0   20.0    8.7   18.9        0 20613      .580      8.60       4
------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2   FAC.       HP  ALDE.      HC       CO     NO2
------------------------------------------------------------------------------------
  1    0.0  344.3     319     2.1   .070      0.0      I       R        R       R
  2    0.0  340.7     274     2.1   .060       .1    0.0  372.73    299.3     2.3
  3    0.0  131.0     245     4.4   .060       .2    0.0   33.73     63.1     1.1
  4    0.0   27.5     188    12.0   .050       .4    0.0    3.08     21.1     1.4
  5    0.0   15.4     202     6.5   .030       .4    0.0    1.24     16.4      .5
  6    0.0   20.1     199    61.7   .060      1.5    0.0     .82      8.1     2.5
  7    0.0   31.1     224   207.4  0.000      0.0    0.0     .84      6.1     5.6
  8    0.0   39.4     661   393.8   .040      1.6    0.0     .97     16.4     9.7
  9    0.0   53.8     787   443.9  0.000      0.0    0.0    1.18     17.3     9.8
 10    0.0  109.3    8763   207.3  0.000      0.0    0.0    2.22    177.6     4.2
 11    0.0  301.3     373     2.3   .070      0.0      I       R        R       R
 12    0.0  314.2     352     2.2   .120      0.0      I       R        R       R
 13    0.0  200.7   20113   477.7   .025      2.7    0.0    1.89    189.0     4.5
 14    0.0  115.2    5169   783.0   .055      5.3    0.0    1.19     53.4     8.1
 15    0.0  109.5    5083   573.9   .035      3.1    0.0    1.26     58.3     6.6
 16    0.0   89.7    4241   406.6   .060      4.8    0.0    1.13     53.2     5.1
 17    0.0   37.2    1027   178.6   .060      3.2    0.0     .70     19.2     3.3
 18    0.0    8.0     192    59.6  0.000      0.0    0.0     .30      7.2     2.2
 19    0.0   10.4     187    12.8   .065      1.3    0.0     .54      9.7      .7
 20    0.0   14.2     156    17.7  0.000      0.0    0.0    1.71     18.7     2.1
 21    0.0   39.6     194     9.9  0.000      0.0    0.0   18.09     88.7     4.5
 22    0.0  241.3     330     2.3   .080      0.0      I       R        R       R
 23    0.0  723.6     411      .5   .060      0.0      I       R        R       R

CYCLE COMPOSITE     HC      8.417    GRAM/BHP HR
                    CO     62.101    GRAM/BHP HR
                    NO2     5.412    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .753      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
  6-29-72 RUN 1   ENG. 2-3, 1972 VERSION,  TIMING  4 ATDC W/EGR
-------------------------------------------------------------------------------------
                  DYNA.             MAN. FUEL    A/F                  DRY CONCENTRATION
MODE SPEED        LOAD     HP     VAC. LB/HR   RATIO    ALDE.      HC        CO       CO2     NO
-------------------------------------------------------------------------------------
   1   600         0.0      0     16.5   4.7    15.3        0    1984      .700     13.77     65
   2  1200         3.0      1     13.0   9.8    13.1        0   20565      .470     11.60     28
   3  1200        13.0      3      7.4  14.2    15.8        0     735      .130     14.05     67
   4  1200        24.0      7      6.4  15.5    15.4        0     307      .150     14.66     98
   5  1200        41.0      9      5.9  16.3    15.2        0     626      .250     14.66    117
   6  1200        81.0     19      4.6  18.7    15.3        0    1296      .250     14.53    280
   7  1200       122.0     28      3.0  21.2    15.1        0    1207      .350     14.66    720
   8  1200       133.0     30      2.7  22.1    15.1        0    1161      .390     14.53    450
   9  1200       149.0     34      1.8  24.0    14.9        0    2280      .740     14.42   1125
  10  1200       162.0     37       .2  30.3    12.8        0    2518     5.450     11.60    500
  11   600         0.0      0     16.7   4.1    14.5        0    2491     1.200     13.91     65
  12  1200         0.0      0     22.0   4.4    15.5        0   46259      .200      8.75     15
  13  2300       206.0     90       .5  64.1    12.5        0    2243     6.020     10.66    500
  14  2300       189.0     83      2.8  47.1    14.4        0    1154     1.800     13.63    438
  15  2300       169.0     74      3.9  44.4    14.3        0    1029     1.980     13.48    600
  16  2300       155.0     68      4.4  43.0    14.3        0     971     1.440     13.48    470
  17  2300       103.0     45      6.5  34.7    14.4        0     948     1.550     13.77    300
  18  2300        52.0     23      9.9  25.2    16.3        0      25      .020     13.48    165
  19  2300        37.0     16     11.8  22.3    16.4        0      28      .020     13.48    126
  20  2300        16.0      7     14.4  17.7    16.3        0      74      .100     13.48     90
  21  2300         4.0      2     16.0  14.1    16.3        0     619      .130     13.48     68
  22   600         0.0      0     16.5   4.0    15.3        0    1515      .550     13.77     65
  23  2300         0.0      0     24.2   4.1    18.0        0   28256      .350      9.03     18
-------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2   FAC.       HP   ALDE.       HC       CO     NO2
-------------------------------------------------------------------------------------
   1   0.0    28.8     206      3.1   .070      0.0       I        R        R       R
   2   0.0   647.1     299      3.0   .060       .0     0.0   944.11    435.8     4.3
   3   0.0    33.2     119     10.1   .060       .2     0.0    11.19     40.0     3.4
   4   0.0    14.5     144     15.3   .050       .3     0.0     2.19     21.7     2.3
   5   0.0    30.4     249     14.3   .030       .3     0.0     3.30     26.6     2.1
   6   0.0    23.7     287     52.9   .060      1.1     0.0     3.98     15.5     2.9
   7   0.0    26.7     449    151.9  0.000      0.0     0.0     2.75     16.1     5.5
   8   0.0    27.4     525     99.6   .040      1.2     0.0     2.55     17.3     3.3
   9   0.0   161.3    1058    264.2  0.000      0.0     0.0     4.74     31.1     7.8
  10   0.0   200.0    8745    131.9  0.000      0.0     0.0     5.40    236.3     3.6
  11   0.0    24.0     424      2.5   .070      0.0       I        R        R       R
  12   0.0   660.7     200       .7   .120      0.0       I        R        R       R
  13   0.0   468.9   20966    283.8   .025      2.3     0.0     5.20    232.4     3.1
  14   0.0   158.6    4997    427.8   .055      4.6     0.0     1.92     60.4     5.2
  15   0.0   133.1    5176    257.8   .035      2.6     0.0     1.80     69.9     3.5
  16   0.0   122.1    4926    196.1   .060      4.1     0.0     1.80     72.6     2.9
  17   0.0    46.8    3147    101.7   .060      2.7     0.0     2.15     70.9     2.3
  18   0.0     2.1     119     46.2  0.000      0.0     0.0      .09      5.2     2.0
  19   0.0     2.1     106     31.3   .065      1.1     0.0      .13      6.5     1.9
  20   0.0     4.4     119     17.7  0.000      0.0     0.0      .63     17.0     2.5
  21   0.0    29.0     123     10.5  0.000      0.0     0.0    16.54     70.1     6.0
  22   0.0    19.0     139      2.7   .080      0.0       I        R        R       R
  23   0.0   430.5     108       .9   .060      0.0       I        R        R       R

CYCLE COMPOSITE      HC       9.763    GRAM/BHP HR
                     CO      80.339    GRAM/BHP HR
                     NO2      3.413    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .897      LB/BHP HR
```

ENGINE 2-3

EFFECT OF FACTORY EGR ON EMISSIONS

GRAPHED RESULTS

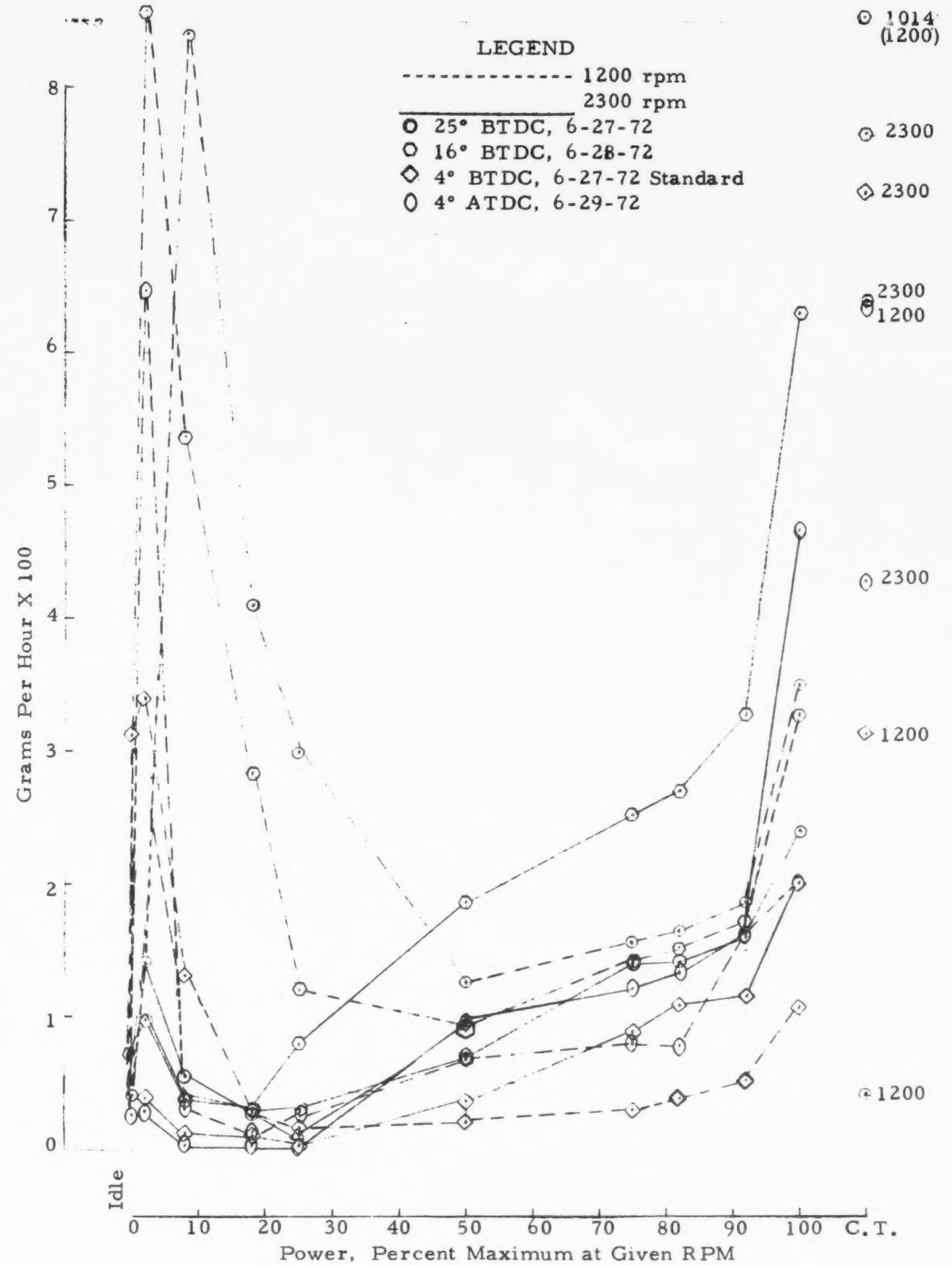


FIGURE K-1. EFFECT OF POWER ON HC EMISSION RATE - FACTORY EGR ENGINE 2-3, 23 MODE TEST

259

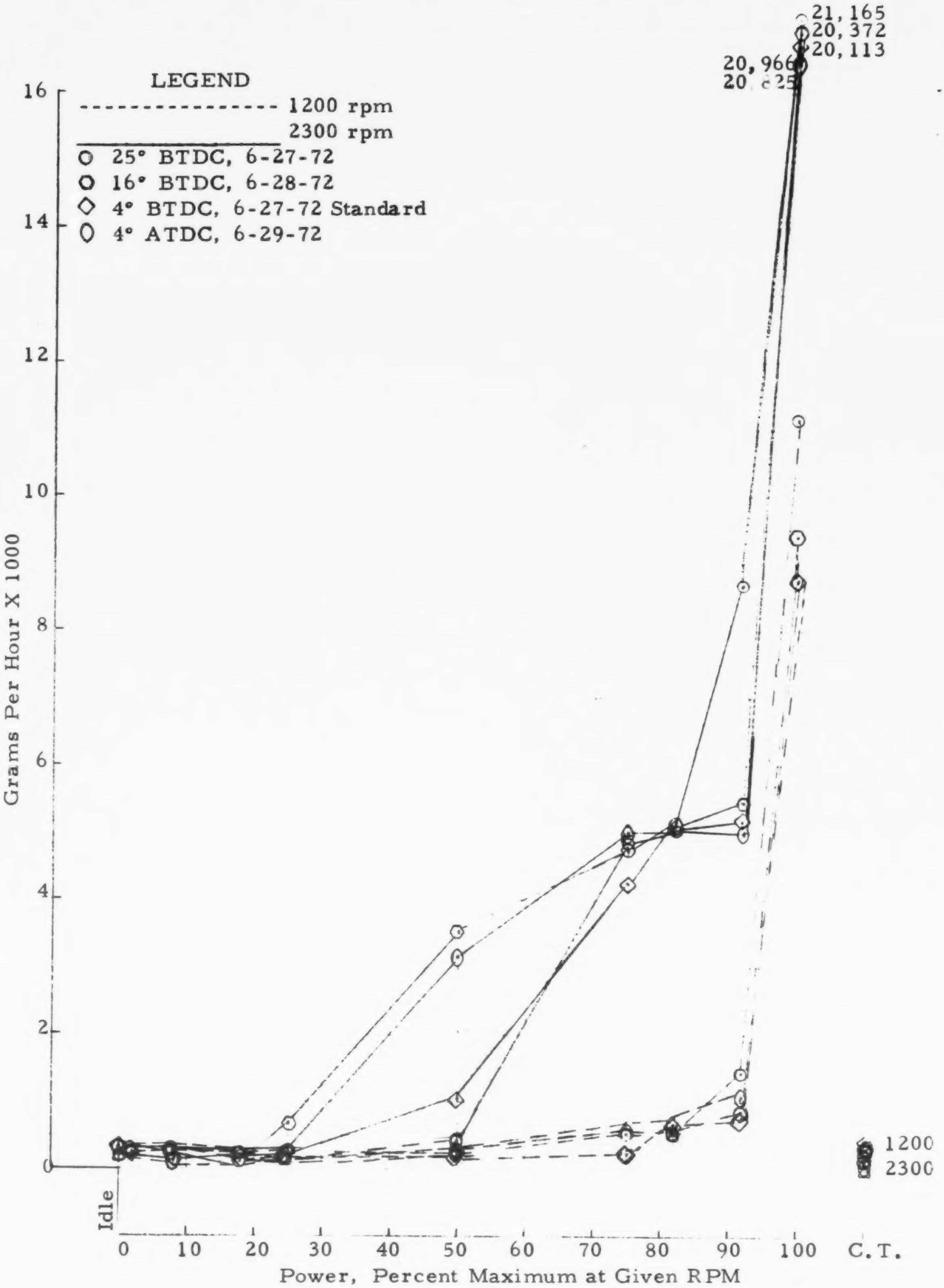


FIGURE K-2. EFFECT OF POWER ON CO EMISSION RATE - FACTORY EGR
ENGINE 2-3, 23 MODE TEST

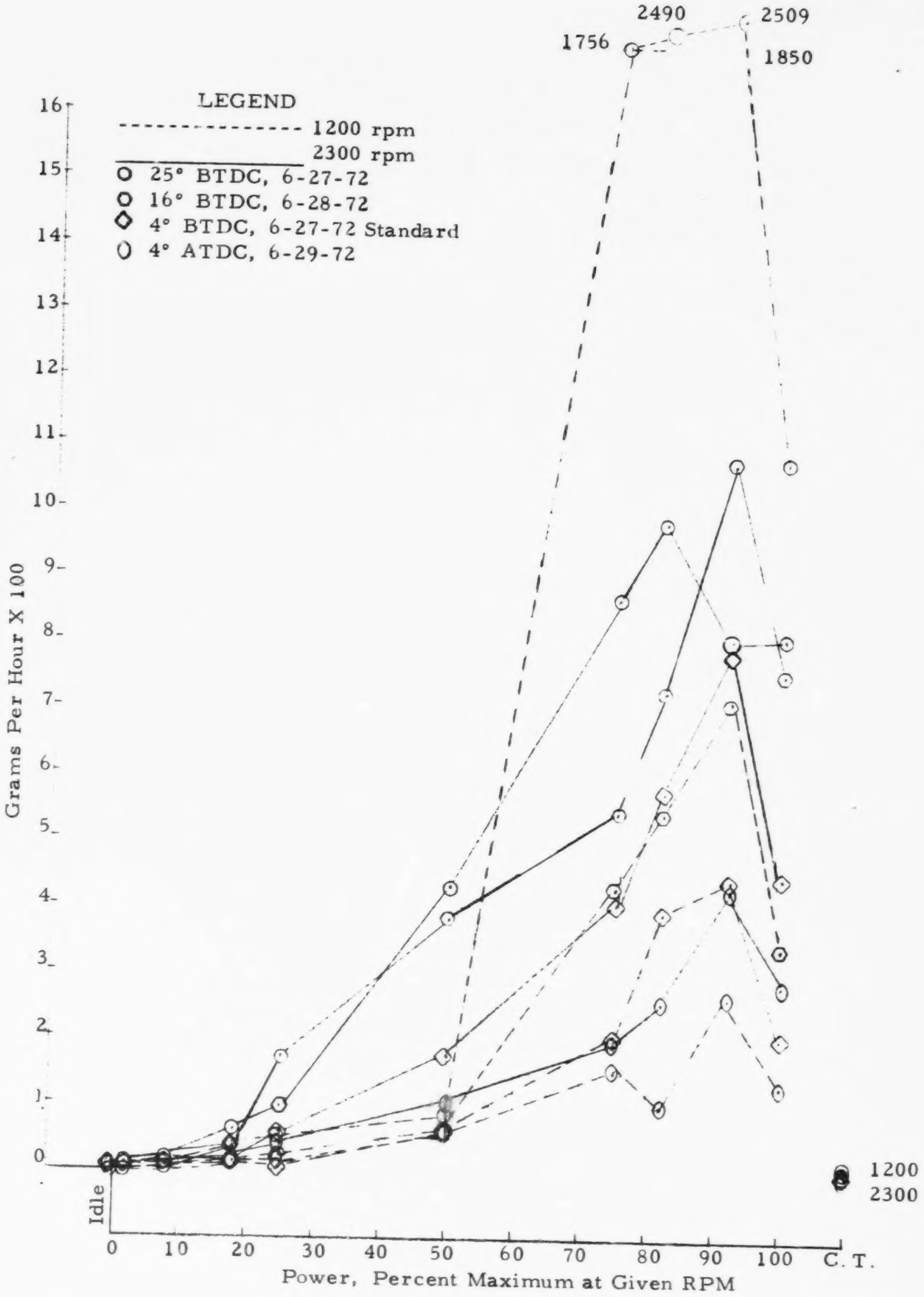


FIGURE K-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE - FACTORY EG
ENGINE 2-3, 23 MODE TEST

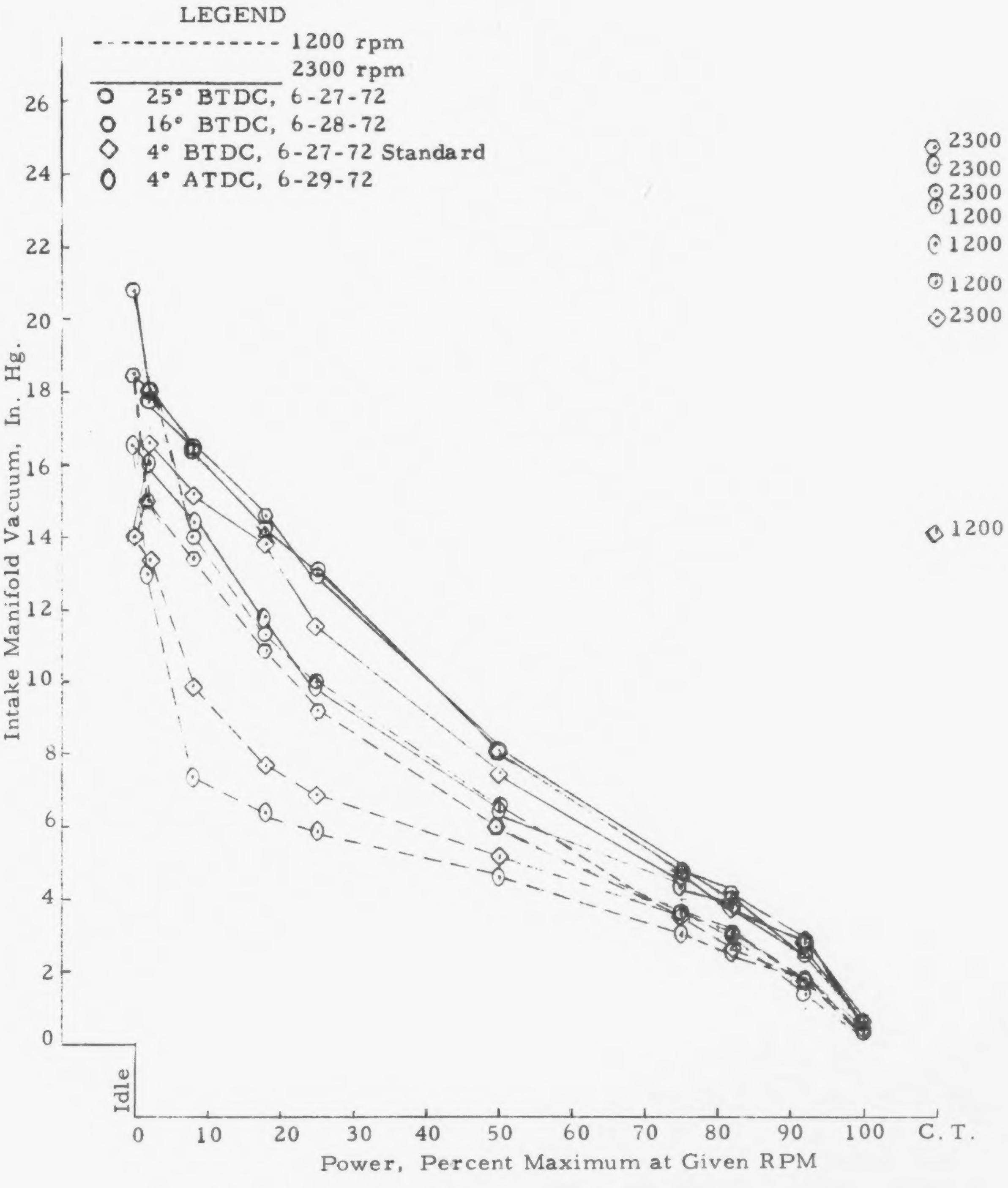


FIGURE K-4. MANIFOLD VACUUM AS A FUNCTION OF POWER - FACTORY EGR
ENGINE 2-3, 23 MODE TEST

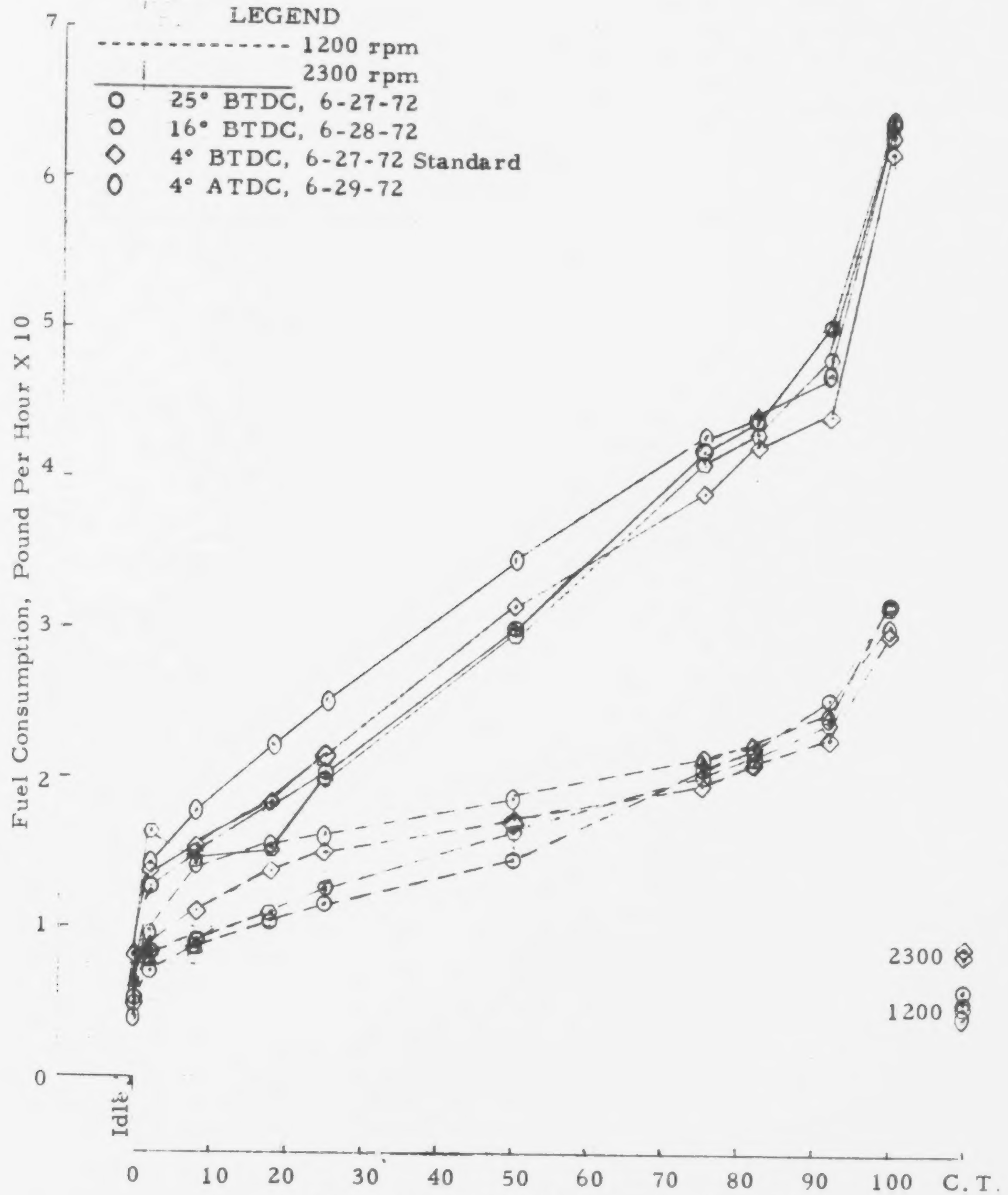


FIGURE K-5. FUEL CONSUMPTION AS A FUNCTION OF POWER - FACTORY EGR ENGINE 2-3, 23 MODE TEST

APPENDIX L

ENGINE 2-3

EFFECT OF LABORATORY EGR ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 2-3

EFFECT OF LABORATORY EGR ON EMISSIONS

TABULAR DATA

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-18-72 RUN-1       ENG. 2-3  1972 VERSION W/EGR MANIFOLD -NO EGR
------------------------------------------------------------------------------------------
                 DYNA.           MAN. FUEL     A/F                   DRY CONCENTRATION
MODE SPEED       LOAD     HP     VAC. LB/HR    RATIO    ALDE.     HC        CO        CO2       NO
------------------------------------------------------------------------------------------
  1   600        0.0       0    17.5    3.6    16.7        0    3420     .420     12.71       39
  2  1200        4.0       1    19.4    7.3    16.6        0     721     .150     13.48       68
  3  1200       18.0       4    18.4    8.1    16.6        0     800     .150     13.48      119
  4  1200       40.0       9    17.2    9.2    16.5        0    1396     .150     13.48      350
  5  1200       56.0      13    16.4   10.2    16.5        0    1531     .150     13.48      490
  6  1200      112.0      26    10.5   14.1    16.5        0    1385     .130     13.48     1125
  7  1200      168.0      38     4.5   21.4    16.2        0    1230     .130     13.77     1550
  8  1200      184.0      42     3.5   22.4    16.0        0    1242     .150     13.77     1750
  9  1200      206.0      47     2.0   24.5    15.7        0    1368     .350     13.77     1625
 10  1200      224.0      51      .6   26.2    15.3        0    1758     .770     13.77     1712
 11   600        0.0       0    17.5    3.6    15.7        0    2459     .640     13.48       51
 12  1200        0.0       0    22.5    3.8    15.9        0   55569     .420      7.00       12
 13  2300      244.0     107      .8   69.0    12.2        0    4146    7.340      9.93      640
 14  2300      224.0      98     3.3   48.9    14.6        0    1680    1.800     13.63     1537
 15  2300      200.0      88     5.0   42.8    15.2        0    1046    1.010     13.77     1675
 16  2300      183.0      80     5.8   41.2    15.7        0     730     .520     13.77     1563
 17  2300      122.0      53    11.9   30.1    16.2        0     892     .180     13.77     2100
 18  2300       61.0      27    16.6   19.6    16.7        0     598     .150     13.63     1087
 19  2300       44.0      19    18.0   16.9    16.8        0     417     .150     13.48      580
 20  2300       20.0       9    19.5   14.6    16.9        0     320     .130     13.33      395
 21  2300        5.0       2    20.3   12.5    17.2        0     188     .130     13.18      190
 22   600        0.0       0    17.7    3.6    17.1        0     287     .440     12.94       44
 23  2300        0.0       0    24.7    3.6    18.3        0   40310     .350      7.25       11
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR              WT.       WT.   BRAKE  SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO      NO2    FAC.       HP   ALDE.       HC       CO      NO2
------------------------------------------------------------------------------------------
  1   0.0     41.5       103      1.6    .070       0.0      I        R        R        R
  2   0.0     17.4        73      5.4    .060        .1    0.0    19.06     80.1      5.9
  3   0.0     21.4        81     10.6    .060        .2    0.0     5.21     19.7      2.6
  4   0.0     42.3        92     35.2    .050        .5    0.0     4.63     10.0      3.9
  5   0.0     51.4       102     54.6    .030        .4    0.0     4.02      7.9      4.3
  6   0.0     64.4       122    173.8    .060       1.5    0.0     2.52      4.8      6.8
  7   0.0     85.2       182    356.2   0.000       0.0    0.0     2.22      4.7      9.3
  8   0.0     89.8       219    420.3    .040       1.7    0.0     2.14      5.2     10.0
  9   0.0    106.6       551    420.5   0.000       0.0    0.0     2.27     11.7      8.9
 10   0.0    142.0      1256    459.2   0.000       0.0    0.0     2.77     24.5      9.0
 11   0.0     28.0       147      1.9    .070       0.0      I        R        R        R
 12   0.0    738.1       113       .5    .120       0.0      I        R        R        R
 13   0.0    733.8     26241    376.0    .025       2.7    0.0     6.87    245.6      3.5
 14   0.0    238.9      5171    725.9    .055       5.4    0.0     2.44     52.7      7.4
 15   0.0    136.4      2661    725.3    .035       3.1    0.0     1.56     30.4      8.3
 16   0.0     95.0      1367    675.0    .060       4.8    0.0     1.19     17.1      8.4
 17   0.0     86.7       354    678.0    .060       3.2    0.0     1.62      6.6     12.7
 18   0.0     38.4       195    231.9   0.000       0.0    0.0     1.44      7.3      8.7
 19   0.0     23.4       170    108.0    .065       1.3    0.0     1.21      8.8      5.6
 20   0.0     15.7       129     64.4   0.000       0.0    0.0     1.80     14.7      7.3
 21   0.0      8.0       112     26.8   0.000       0.0    0.0     3.65     51.0     12.3
 22   0.0      3.5       108      1.8    .080       0.0      I        R        R        R
 23   0.0    542.6        95       .5    .060       0.0      I        R        R        R

CYCLE COMPOSITE    HC       7.609    GRAM/BHP HR
                   CO      49.526    GRAM/BHP HR
                   NO2      7.876    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .654      LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-19-72 RUN-1   ENG. 2-3  1972 VERSION W/EGR MAN NO EGR S+D TIMING
-----------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO   ALDE.     HC      CO      CO2     NO
-----------------------------------------------------------------------------
  1   600      0.0     0  17.3   3.2   17.1        0  7783    .180   11.92     34
  2  1200      5.0     1  19.1   7.4   16.4        0   467    .150   13.48     76
  3  1200     18.0     4  18.6   8.2   16.4        0   901    .150   13.48    182
  4  1200     41.0     9  17.3  11.3   17.3        0   916    .150   12.47    320
  5  1200     58.0    13  15.8  13.2   17.4        0  1005    .150   12.47    530
  6  1200    115.0    26   9.8  14.1   17.0        0   906    .130   12.71    925
  7  1200    173.0    40   3.9  21.6   16.6        0   910    .130   13.18   1450
  8  1200    189.0    43   2.8  22.4   16.5        0   865    .130   13.18   1500
  9  1200    212.0    48   1.2  24.7   16.2        0  1146    .130   13.18   1850
 10  1200    230.0    53    .5  31.9   13.4        0   291   5.240   11.24    738
 11   600      0.0     0  17.8   3.4   16.1        0  2414    .210   13.06     48
 12  1200      0.0     0  22.8   3.2   16.1        0 54316    .390    6.64     11
 13  2300    244.0   107    .2  62.8   13.0        0  2503   5.190   11.13    975
 14  2300    224.0    98   3.0  48.8   14.3        0  1677   2.280   12.94   1475
 15  2300    200.0    88   4.4  43.3   15.5        0   634    .610   13.63   1675
 16  2300    183.0    80   5.4  42.1   15.6        0   712    .520   13.48   1662
 17  2300    122.0    53  10.9  30.2   16.2        0   636    .150   13.48   1487
 18  2300     61.0    27  16.4  19.4   16.8        0   527    .150   12.94   1175
 19  2300     44.0    19  17.5  17.7   16.8        0   448    .130   12.94   2287
 20  2300     20.0     9  19.6  12.8   17.0        0   230    .130   13.06    320
 21  2300      5.0     2  20.5  12.3   17.1        0   160    .180   12.82    180
 22   600      0.0     0  18.3   3.2   17.3        0  3235    .250   12.22     39
 23  2300      0.0     0  24.8   3.4   21.5        0 44869    .250    4.45      7
-----------------------------------------------------------------------------
        CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC       CO     NO2
-----------------------------------------------------------------------------
  1    0.0    87.7      41     1.3  .070     0.0     I        R        R       R
  2    0.0    11.5      74     6.2  .060      .1   0.0    10.04     65.1     5.4
  3    0.0    24.4      82    16.4  .060      .2   0.0     5.94     20.0     4.0
  4    0.0    36.9     122    42.8  .050      .5   0.0     3.94     13.0     4.6
  5    0.0    47.3     143    82.8  .030      .4   0.0     3.57     10.8     6.2
  6    0.0    44.8     130   151.9  .060     1.6   0.0     1.71      4.9     5.8
  7    0.0    66.5     192   352.0 0.000     0.0   0.0     1.68      4.9     8.9
  8    0.0    65.6     199   377.7  .040     1.7   0.0     1.52      4.6     8.7
  9    0.0    95.6     219   512.6 0.000     0.0   0.0     1.97      4.5    10.6
 10    0.0    25.5    9277   214.6 0.000     0.0   0.0      .49    176.5     4.1
 11    0.0    27.6      48     1.8  .070     0.0     I        R        R       R
 12    0.0   632.7      92      .4  .120     0.0     I        R        R       R
 13    0.0   430.3   18023   556.5  .025     2.7   0.0     4.03    168.7     5.2
 14    0.0   241.2    6625   704.4  .055     5.4   0.0     2.46     67.5     7.2
 15    0.0    87.0    1692   763.6  .035     3.1   0.0      .99     19.3     8.7
 16    0.0    96.6    1426   748.8  .060     4.8   0.0     1.21     17.8     9.3
 17    0.0    63.6     303   659.9  .060     3.2   0.0     1.19      5.7    12.4
 18    0.0    35.3     203   261.2 0.000     0.0   0.0     1.32      7.6     9.8
 19    0.0    27.4     161   464.9  .065     1.3   0.0     1.42      8.3    24.1
 20    0.0    10.1     115    46.7 0.000     0.0   0.0     1.15     13.2     5.3
 21    0.0     6.8     156    25.6 0.000     0.0   0.0     3.13     71.2    11.7
 22    0.0    36.7      57     1.5  .080     0.0     I        R        R       R
 23    0.0   253.2      85      .4  .060     0.0     I        R        R       R

CYCLE COMPOSITE     HC       7.287    GRAM/BHP HR
                    CO      42.229    GRAM/BHP HR
                    NO2      9.032    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .651      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-14-72 RUN-2    ENG.2-3   1972 VERSION -STD W/EGR-MANIFOLD NO-EGR
--------------------------------------------------------------------------------
            DYNA.        MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED  LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC        CO       CO2     NO
--------------------------------------------------------------------------------
  1   600     0.0    0  18.2   3.3   16.5       0  2386      .350     12.94     50
  2  1200     5.0    1  19.5   7.1   17.0       0   538      .130     12.94     58
  3  1200    18.0    4  18.8   7.5   16.8       0   908      .150     12.94    128
  4  1200    41.0    9  17.5   9.0   16.6       0  1460      .130     13.18    450
  5  1200    58.0   13  16.6   9.8   16.8       0  1515      .130     13.06    600
  6  1200   115.0   26   9.8  15.7   17.2       0  1029      .130     12.71    800
  7  1200   173.0   40   4.0  21.6   16.5       0   965      .150     13.06    142
  8  1200   189.0   43   2.9  22.5   16.6       0   876      .130     13.18   1575
  9  1200   212.0   48   1.3  23.9   16.0       0  1152      .210     13.77   1875
 10  1200   230.0   53    .5  31.2   13.3       0  2907     4.880     11.48    870
 11   600     0.0    0  18.2   3.2   16.5       0  2021      .440     12.82     46
 12  1200     0.0    0  22.9   3.5   19.8       0 50331      .310      4.94      7
 13  2300   248.0  109    .9  62.8   13.0       0  2535     5.350     11.13   1075
 14  2300   228.0  100   2.9  49.6   14.5       0  1667     1.870     13.48   1625
 15  2300   203.0   89   4.4  44.3   15.4       0   680      .700     13.77   1700
 16  2300   186.0   81   5.5  42.2   15.4       0   862      .740     13.77   1650
 17  2300   124.0   54  11.1  29.7   16.3       0   677      .180     13.63   2037
 18  2300    62.0   27  16.4  19.6   16.8       0   539      .150     13.06   1175
 19  2300    45.0   20  17.7  17.4   16.9       0   410      .150     13.18    800
 20  2300    20.0    9  19.5  13.9   17.0       0   221      .130     12.94    330
 21  2300     5.0    2  20.4  12.7   17.1       0   159      .130     13.06    200
 22   600     0.0    0  18.3   3.4   17.6       0  2092      .310     12.22     42
 23  2300     0.0    0  24.9   3.5   25.4       0 46340      .180      3.04      5
--------------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.       HP  ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0    26.4     78     1.8  .070      0.0      I       R        R        R
  2    0.0    13.2     64     4.7  .060       .1    0.0   11.56     56.4      4.1
  3    0.0    23.4     78    11.0  .060       .2    0.0    5.70     19.0      2.7
  4    0.0    44.3     80    45.3  .050       .5    0.0    4.73      8.5      4.8
  5    0.0    50.5     87    65.4  .030       .4    0.0    3.81      6.6      5.0
  6    0.0    56.6    144   146.1  .060      1.6    0.0    2.16      5.5      5.6
  7    0.0    71.1    223    34.8 0.000      0.0    0.0    1.80      5.6       .9
  8    0.0    66.7    200   398.3  .040      1.7    0.0    1.55      4.6      9.2
  9    0.0    88.6    326   478.8 0.000      0.0    0.0    1.83      6.7      9.9
 10    0.0   247.1   8378   245.5 0.000      0.0    0.0    4.70    159.4      4.7
 11    0.0    21.8     96     1.6  .070      0.0      I       R        R        R
 12    0.0   777.1     97      .4  .120      0.0      I       R        R        R
 13    0.0   431.6  18397   607.6  .025      2.7    0.0    3.97    169.4      5.6
 14    0.0   241.8   5477   782.3  .055      5.5    0.0    2.42     54.9      7.8
 15    0.0    94.0   1954   780.1  .035      3.1    0.0    1.06     22.0      8.8
 16    0.0   113.0   1960   718.4  .060      4.9    0.0    1.39     24.1      8.8
 17    0.0    65.7    353   656.7  .060      3.3    0.0    1.21      6.5     12.1
 18    0.0    36.1    203   261.5 0.000      0.0    0.0    1.33      7.5      9.6
 19    0.0    24.2    179   156.8  .065      1.3    0.0    1.23      9.1      8.0
 20    0.0    10.6    126    52.8 0.000      0.0    0.0    1.21     14.4      6.0
 21    0.0     7.0    115    29.0 0.000      0.0    0.0    3.17     52.3     13.2
 22    0.0    25.3     76     1.7  .080      0.0      I       R        R        R
 23    0.0   936.7     73      .3  .060      0.0      I       R        R        R

CYCLE COMPOSITE     HC      8.186    GRAM/BHP HR
                    CO     41.463    GRAM/BHP HR
                    NO2     8.266    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .639      LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-26-72 RUN 1   ENC-2-3  1972-VERSION-5  EGR STD TIMING
--------------------------------------------------------------------------------
              DYNA.         MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO   ALDE.     HC       CO      CO2      NO
--------------------------------------------------------------------------------
  1   600      0.0     0  18.4    3.3   16.6       0   5387    .740    12.47      33
  2  1200      5.0     1  19.3    7.5   15.9       0    759    .390    14.05      72
  3  1200     18.0     4  18.8    7.8   16.3       0    949    .150    13.91     120
  4  1200     40.0     9  16.8    9.1   17.4       0   1502    .130    12.94     270
  5  1200     55.0    13  15.0    9.9   18.6       0   1623    .130    11.92     195
  6  1200    110.0    25   7.9   16.5   17.8       0    660    .100    12.71     480
  7  1200    165.0    38   3.4   20.3   17.3       0    600    .100    12.94     900
  8  1200    180.0    41   2.4   21.3   17.2       0    628    .100    12.44    1250
  9  1200    202.0    46   1.3   22.9   16.6       0    929    .100    13.48    1563
 10  1200    220.0    50    .5   28.6   13.5       0   2908   4.300    12.09     645
 11   600      0.0     0  18.7    3.5   15.1       0   3967   1.940    12.47      43
 12  1200      0.0     0  23.3    3.6   16.3       0  57923    .490     6.30      11
 13  2300    225.0    99    .9   58.2   13.1       0   2802   4.880    11.92     480
 14  2300    207.0    91   2.8   44.4   15.4       0    865    .520    14.42    1462
 15  2300    185.0    81   3.9   41.7   15.6       0    557    .440    14.42    1125
 16  2300    169.0    74   4.6   40.5   15.8       0    397    .350    14.31    1050
 17  2300    113.0    49   8.2   32.3   17.2       0    103    .130    13.48     770
 18  2300     56.0    25  14.7   19.7   18.6       0    368    .210    12.22     310
 19  2300     41.0    18  16.1   17.9   18.7       0    318    .210    12.22     260
 20  2300     18.0     8  18.9   13.8   18.5       0    262    .180    12.47     122
 21  2300      5.0     2  19.4   13.0   18.4       0    341    .180    12.47     110
 22   600      0.0     0  18.4    3.4   16.2       0   3396   1.090    13.18      41
 23  2300      0.0     0  25.2    3.4   20.0       0  47011    .350     5.75       9
--------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC      CO     NO2   FAC.      HP   ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0    58.6    163     1.2  .070     0.0       I       R        R        R
  2    0.0    17.8    185     5.6  .060      .1     0.0   15.58    161.6      4.9
  3    0.0    23.7     76    10.0  .060      .2     0.0    5.77     18.4      2.4
  4    0.0    46.9     82    28.0  .050      .5     0.0    5.13      9.0      3.1
  5    0.0    59.7     97    23.8  .030      .4     0.0    4.75      7.7      1.9
  6    0.0    38.4    117    92.6  .060     1.5     0.0    1.53      4.7      3.7
  7    0.0    42.1    142   210.0 0.000     0.0     0.0    1.12      3.8      5.6
  8    0.0    46.3    149   306.0  .040     1.6     0.0    1.13      3.6      7.4
  9    0.0    70.5    153   394.1 0.000     0.0     0.0    1.53      3.3      8.5
 10    0.0   226.1   6755   166.5 0.000     0.0     0.0    4.50    134.4      3.3
 11    0.0    42.5    420     1.5  .070     0.0       I       R        R        R
 12    0.0   751.7    128      .5  .120     0.0       I       R    .   R        R
 13    0.0   433.1  15236   246.3  .025     2.5     0.0    4.40    154.6      2.5
 14    0.0   115.9   1408   659.8  .055     5.0     0.0    1.28     15.5      7.2
 15    0.0    70.7   1127   473.6  .035     2.8     0.0     .87     13.9      5.8
 16    0.0    49.7    884   435.7  .060     4.4     0.0     .67     11.9      5.9
 17    0.0    11.1    282   275.0  .060     3.0     0.0     .22      5.7      5.6
 18    0.0    26.4    304    73.8 0.000     0.0     0.0    1.08     12.4      3.0
 19    0.0    20.7    276    56.2  .065     1.2     0.0    1.15     15.4      3.1
 20    0.0    13.0    180    20.1 0.000     0.0     0.0    1.64     22.8      2.5
 21    0.0    15.8    169    17.0 0.000     0.0     0.0    7.23     77.2      7.8
 22    0.0    35.8    232     1.4  .080     0.0       I       R        R        R
 23    0.0   671.2    101      .4  .060     0.0       I       R        R        R

CYCLE COMPOSITE    HC      7.593   GRAM/BHP HR
                   CO     30.315   GRAM/BHP HR
                   NO2     5.442   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .681     LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-24-72 RUN-2   ENG.2-3   1972 VERSION-10 -EGR STD TIMING
-------------------------------------------------------------------------------------
              DYNA.         MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
-------------------------------------------------------------------------------------
  1    600      0.0    0   18.5    3.4    16.3       0   5941     .740     12.34      34
  2   1200      4.0    1   19.7    6.8    16.7       0    592     .070     13.77     102
  3   1200     11.0    3   19.2    7.8    16.7       0    546     .070     13.48     104
  4   1200     39.0    9   16.8    8.5    18.2       0   1866     .070     11.92     157
  5   1200     54.0   12   15.6    9.8    18.6       0   1497     .070     11.72     255
  6   1200    107.0   24    6.6   16.4    18.4       0    508     .070     12.59     240
  7   1200    161.0   37    3.2   19.7    17.9       0    586     .070     12.59     620
  8   1200    175.0   40    2.3   20.6    17.5       0    604     .070     12.71     937
  9   1200    197.0   45     .9   22.6    16.8       0    910     .070     13.33    1175
 10   1200    214.0   49     .5   27.4    13.8       0   2871    3.560     12.47     535
 11    600      0.0    0   18.0    2.1    15.4       0   3913    1.340     13.18      46
 12   1200      0.0    0   23.2    3.3    17.0       0  59803     .440      5.88      10
 13   2300    202.0   88     .9   54.7    13.2       0   2859    4.540     12.22     245
 14   2300    186.0   81    2.5   44.4    15.2       0    762     .520     14.31     520
 15   2300    166.0   73    3.2   41.3    15.7       0    420     .180     14.31     430
 16   2300    152.0   67    3.7   40.1    16.2       0    255     .150     14.05     410
 17   2300    101.0   44    7.3   33.5    16.6       0    282     .150     13.77     225
 18   2300     51.0   22   10.5   25.3    18.4       0    713     .180     12.09     107
 19   2300     36.0   16   13.4   20.5    18.2       0   3798     .280     11.48      80
 20   2300     16.0    7   16.3   16.1    19.1       0   2744     .280     11.48      71
 21   2300      4.0    2   18.3   13.3    18.9       0  10815     .310     10.89      38
 22    600      0.0    0   18.5    3.5    15.3       0   3895    1.480     13.35      41
 23   2300      0.0    0   25.1    3.6    16.2       0  44664     .470      8.14      13
-------------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECTFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2   FAC.      HP   ALDE.      HC       CO      NO2
-------------------------------------------------------------------------------------
  1    0.0    67.0     169      1.3   .070     0.0      I        R        R        R
  2    0.0    13.1      31      7.6   .060      .1    0.0    14.38     34.3      8.3
  3    0.0    14.2      37      4.4   .060      .2    0.0     5.65     14.6      3.7
  4    0.0    54.1      45     16.5   .050      .4    0.0     6.63      5.0      1.9
  5    0.0    55.7      53     31.5   .030      .4    0.0     4.52      4.3      2.6
  6    0.0    29.7      83     46.6   .060     1.5    0.0     1.22      3.4      1.9
  7    0.0    41.2      99    144.6  0.000     0.0    0.0     1.12      2.7      3.9
  8    0.0    43.9     103    226.4   .040     1.6    0.0     1.10      2.6      5.7
  9    0.0    69.2     107    296.4  0.000     0.0    0.0     1.54      2.4      6.6
 10    0.0   218.7    5478    135.3  0.000     0.0    0.0     4.47    112.0      2.8
 11    0.0    25.0     173      1.0   .070     0.0      I        R        R        R
 12    0.0   727.8     108       .4   .120     0.0      I        R        R        R
 13    0.0   416.1   13349    118.4   .025     2.2    0.0     4.70    150.9      1.3
 14    0.0   102.9    1419    233.3   .055     4.5    0.0     1.26     17.4      2.9
 15    0.0    54.1     469    184.0   .035     2.5    0.0      .74      6.4      2.5
 16    0.0    32.5     387    174.0   .060     4.0    0.0      .49      5.8      2.6
 17    0.0    30.7     330     81.4   .060     2.7    0.0      .70      7.5      1.8
 18    0.0    66.3     338     33.2  0.000     0.0    0.0     2.97     15.1      1.5
 19    0.0   290.9     433     20.5   .065     1.0    0.0    18.45     27.5      1.3
 20    0.0   166.5     343     14.4  0.000     0.0    0.0    23.77     49.0      2.1
 21    0.0   531.3     308      6.3  0.000     0.0    0.0   303.28    175.6      3.6
 22    0.0    40.6     312      1.4   .080     0.0      I        R        R        R
 23    0.0   597.4     114       .5   .060     0.0      I        R        R        R

CYCLE COMPOSITE    HC       8.732    GRAM/BHP HR
                   CO      27.866    GRAM/BHP HR
                   NO2      2.566    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .747      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-24-72 RUN-1   ENG.2-3   1972 VERSION-10 *EGR STD TIMING
---------------------------------------------------------------------------------------------------
              DYNA.         MAN. FUEL    A/F                   DRY CONCENTRATION
MODE SPEED    LOAD     HP   VAC. LB/HR  RATIO     ALDE.     HC        CO        CO2        NO
---------------------------------------------------------------------------------------------------
  1    600     0.0      0  18.5   3.5   15.6          0   4252   1.300     13.18        41
  2   1200     4.0      1  19.7   7.6   15.7          0    869    .580     14.05        88
  3   1200    15.0      3  19.0   8.1   15.9          0    906    .310     14.05       131
  4   1200    35.0      8  18.1   8.7   16.2          0   1537    .150     13.91       380
  5   1200    48.0     11  17.2  10.0   16.4          0   1578    .150     13.63       490
  6   1200    96.0     22   5.2  18.0   17.3          0    482    .100     12.94       180
  7   1200   144.0     33   1.8  21.4   17.1          0    617    .150     13.06       450
  8   1200   157.0     36   1.3  22.4   16.7          0    642    .150     13.48       540
  9   1200   177.0     40    .9  21.8   16.5          0    705    .150     13.63       620
 10   1200   192.0     44    .4  28.7   13.8          0   2467   4.020     11.92       490
 11    600     0.0      0  18.7   2.8   14.9          0   3354   1.630     13.18        48
 12   1200     0.0      0  23.3   3.4   15.2          0  63006    .700      6.64        12
 13   2300   202.0     88   1.0  53.2   13.6          0   2215   3.840     12.47       290
 14   2300   186.0     81   2.2  44.8   15.1          0    957   1.010     14.05       500
 15   2300   166.0     73   2.6  42.9   15.7          0    545    .350     14.18       490
 16   2300   152.0     67   3.3  40.0   16.1          0    311    .180     14.05       410
 17   2300   101.0     44   8.1  30.6   17.2          0    131    .100     13.18       360
 18   2300    51.0     22  13.9  20.5   18.6          0    534    .180     12.04       270
 19   2300    36.0     16  15.9  17.8   18.9          0    568    .180     12.09       200
 20   2300    16.0      7  17.3  15.5   18.6          0    834    .190     11.92       103
 21   2300     4.0      2  18.8  13.7   18.6          0    623    .150     12.09        76
 22    600     0.0      0  18.5   2.8   15.9          0   3958   1.090     13.06        42
 23   2300     0.0      0  25.2   2.3   17.6          0  46035    .350      7.28        12
---------------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO      NO2   FAC.       HP   ALDE.      HC       CO       NO2
---------------------------------------------------------------------------------------------------
  1    0.0    45.3     280     1.4   .070      0.0       I       R        R         R
  2    0.0    20.3     274     6.8   .060       .1     0.0   22.26    300.3       7.5
  3    0.0    23.0     159    11.1   .060       .2     0.0    6.72     46.5       3.2
  4    0.0    42.7      84    35.0   .050       .4     0.0    5.34     10.5       4.4
  5    0.0    51.4      99    52.9   .030       .3     0.0    4.68      9.0       4.8
  6    0.0    30.1     126    37.3   .060      1.3     0.0    1.37      5.7       1.7
  7    0.0    45.1     222   109.3  0.000      0.0     0.0    1.37      6.7       3.3
  8    0.0    47.6     225   133.0   .040      1.4     0.0    1.33      6.3       3.7
  9    0.0    50.3     216   147.0  0.000      0.0     0.0    1.24      5.3       3.6
 10    0.0   198.4    6531   130.8  0.000      0.0     0.0    4.52    148.9       3.0
 11    0.0    28.1     276     1.3   .070      0.0       I       R        R         R
 12    0.0   712.4     160      .5   .120      0.0       I       R        R         R
 13    0.0   323.4   11323   140.5   .025      2.2     0.0    3.66    128.0       1.6
 14    0.0   128.3    2736   222.6   .055      4.5     0.0    1.58     33.6       2.7
 15    0.0    72.7     943   217.1   .035      2.5     0.0    1.00     13.0       3.0
 16    0.0    39.6     463   173.2   .060      4.0     0.0     .59      6.9       2.6
 17    0.0    13.7     211   124.8   .060      2.7     0.0     .31      4.8       2.8
 18    0.0    40.3     274    67.6  0.000      0.0     0.0    1.81     12.3       3.0
 19    0.0    37.2     238    43.5   .065      1.0     0.0    2.36     15.1       2.8
 20    0.0    48.1     210    19.7  0.000      0.0     0.0    6.87     29.9       2.8
 21    0.0    31.5     153    12.7  0.000      0.0     0.0   17.98     87.4       7.3
 22    0.0    34.6     192     1.2   .080      0.0       I       R        R         R
 23    0.0   392.6      60      .3   .060      0.0       I       R        R         R

CYCLE COMPOSITE     HC      7.276    GRAM/BHP HR
                    CO     31.443    GRAM/BHP HR
                    NO2     2.731    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .753      LB/BHP HR
```

```
                   PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-25-72 RUN2     ENG.2-3  1972 VERSION-15  EGR STD TIMING
------------------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F                  DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO   ALDE.      HC      CO       CO2      NO
------------------------------------------------------------------------------------------
  1    600     0.0     0   18.3   3.0   15.2       0    3172   1.300    13.06      44
  2   1200     4.0     1   18.4   7.2   16.8       0    1796    .180    13.06      45
  3   1200    15.0     3   17.2   7.8   17.7       0    5659    .250    11.60      44
  4   1200    33.0     8   14.0   9.6   18.6       0    4593    .180    11.36      62
  5   1200    46.0    11   13.3   9.6   18.7       0    3735    .180    11.36      68
  6   1200    91.0    21    6.3  16.5   17.5       0     598    .150    12.59     131
  7   1200   137.0    31    1.8  20.8   17.0       0     862    .150    12.82      93
  8   1200     0.0     0    0.0   0.0    0.0       0       0   0.000     0.00       0
  9   1200     0.0     0    0.0   0.0    0.0       0       0   0.000     0.00       0
 10   1200   182.0    42     .5  27.7   13.2       0    3045   4.640    11.48     145
 11    600     0.0     0   18.5   2.7   14.6       0    4206   2.180    12.59      43
 12   1200     0.0     0   23.3   3.1   15.9       0   63177    .470     6.21       9
 13   2300   177.0    78     .9  54.5   13.0       0    3475   5.500    11.60      31
 14   2300   163.0    71    1.9  45.5   14.6       0    1498   1.590    13.91     171
 15   2300   145.0    63    2.3  43.4   15.0       0    1132   1.160    14.31     167
 16   2300   133.0    58    2.4  41.3   15.8       0     443    .180    14.42     186
 17   2300    89.0    39    5.2  35.6   16.5       0    3383    .180    13.63     146
 18   2300    44.0    19    8.7  27.5   17.8       0    5017    .210    12.22      67
 19   2300    32.0    14    9.5  25.9   18.8       0    6103    .250    11.60      53
 20   2300    14.0     6   14.3  18.7   18.7       0    9486    .250    10.89      46
 21   2300     4.0     2   17.9  14.5   18.3       0    6870    .210    11.48      41
 22    600     0.0     0   18.3   3.2   15.6       0    3460    .890    13.63      41
 23   2300     0.0     0   25.2   3.6   18.0       0   45919    .250     7.09      10
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2  FAC.       HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1    0.0    29.4     243     1.4  .070      0.0       I        R        R        R
  2    0.0    43.7      88     3.6  .060       .1     0.0    47.82     96.8      4.0
  3    0.0   161.3     144     4.2  .060       .2     0.0    47.05     42.0      1.2
  4    0.0   166.7     132     7.5  .050       .4     0.0    22.11     17.5      1.0
  5    0.0   136.5     133     8.3  .030       .3     0.0    12.99     12.6       .8
  6    0.0    35.0     177    25.5  .060      1.2     0.0     1.68      8.5      1.2
  7    0.0    62.3     219    22.2 0.000      0.0     0.0     1.99      7.0       .7
  8    0.0     0.0       0     0.0  .040      0.0     0.0     0.00      0.0      0.0
  9    0.0     0.0       0     0.0 0.000      0.0     0.0     0.00      0.0      0.0
 10    0.0   233.0    7170    36.8 0.000      0.0     0.0     5.60    172.4       .9
 11    0.0    33.9     355     1.2  .070      0.0       I        R        R        R
 12    0.0   683.5     103      .3  .120      0.0       I        R        R        R
 13    0.0   492.3   15742    14.6  .025      1.9     0.0     6.35    203.1       .2
 14    0.0   197.5    4236    75.0  .055      3.9     0.0     2.77     59.3      1.1
 15    0.0   143.0    2960    70.3  .035      2.2     0.0     2.25     46.6      1.1
 16    0.0    56.6     465    79.1  .060      3.5     0.0      .97      8.0      1.4
 17    0.0   386.1     415    55.4  .060      2.3     0.0     9.91     10.6      1.4
 18    0.0   484.0     409    21.5 0.000      0.0     0.0    25.12     21.2      1.1
 19    0.0   575.4     476    16.6  .065       .9     0.0    41.06     34.0      1.2
 20    0.0   665.6     354    10.7 0.000      0.0     0.0   108.57     57.8      1.7
 21    0.0   365.1     225     7.3 0.000      0.0     0.0   208.42    128.7      4.2
 22    0.0    33.8     176     1.3  .080      0.0       I        R        R        R
 23    0.0   628.4      69      .4  .060      0.0       I        R        R        R

CYCLE COMPOSITE     HC      14.434    GRAM/BHP HR
                    CO      54.104    GRAM/BHP HR
                    NO2      1.119    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .915      LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-25-72 RUN-1    ENG.2-3   1972 VERSION-20 -EGR STD TIMING
------------------------------------------------------------------------------------------
               DYNA.           MAN. FUEL     A/F            DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
------------------------------------------------------------------------------------------
   1   600      0.0     0   18.5    3.1    15.1        0  4204    1.660    13.06      41
   2  1200      3.0     1   19.2    7.2    15.7        0   839     .280    14.18      57
   3  1200     12.0     3   19.7    7.6    15.6        0   884     .350    14.05      80
   4  1200     28.0     6   15.8    9.1    16.8        0  2803     .150    12.94      88
   5  1200     39.0     9   14.8    9.7    16.0        0  3648     .180    13.06      88
   6  1200      0.0     0    0.0    0.0     0.0        0     0    0.000     0.00       0
   7  1200      0.0     0    0.0    0.0     0.0        0     0    0.000     0.00       0
   8  1200      0.0     0    0.0    0.0     0.0        0     0    0.000     0.00       0
   9  1200      0.0     0    0.0    0.0     0.0        0     0    0.000     0.00       0
  10  1200    154.0    35     .5   25.3    13.4        0  3021    4.070    12.22      76
  11   600      0.0     0   19.0    3.4    14.5        0  4323    2.180    12.71      43
  12  1200      0.0     0   23.3    3.3    15.0        0 60644     .930     7.00      12
  13  2300    152.0    67    1.0   49.7    13.2        0  2965    4.160    12.22      72
  14  2300    140.0    61    1.7   43.6    14.3        0  1833    1.800    13.91     104
  15  2300    125.0    55    1.8   43.0    14.5        0  1783    1.520    13.91      96
  16  2300    114.0    50    2.0   41.8    14.9        0  1436    1.010    14.05      98
  17  2300     76.0    33    3.9   36.5    15.8        0  7863     .390    12.94      88
  18  2300     38.0    17    8.3   28.1    17.2        0  9995     .350    11.60      53
  19  2300     27.0    12    8.9   26.4    17.5        0 13929     .390    11.01      45
  20  2300     12.0     5   10.8   23.4    17.9        0 14788     .420    10.78      35
  21  2300      3.0     1   16.6   15.4    18.4        0 22313     .420     9.14      23
  22   600      0.0     0   18.5    3.3    15.8        0  4802    1.090    12.94      40
  23  2300      0.0     0   25.2    3.4    30.6        0   532     .350     6.56       8
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO    NO2   FAC.      HP  ALDE.      HC       CO     NO2
------------------------------------------------------------------------------------------
   1   0.0    39.0      311    1.3   .070     0.0      I       R        R       R
   2   0.0    18.8      127    4.2   .060      .0    0.0   27.49    185.3     6.2
   3   0.0    21.0      168    6.3   .060      .2    0.0    7.67     61.4     2.3
   4   0.0    86.5       94    9.0   .050      .3    0.0   13.52     14.6     1.4
   5   0.0   118.0      118    9.4   .030      .3    0.0   13.24     13.2     1.1
   6   0.0     0.0        0    0.0   .060     0.0    0.0    0.00      0.0     0.0
   7   0.0     0.0        0    0.0  0.000     0.0    0.0    0.00      0.0     0.0
   8   0.0     0.0        0    0.0   .040     0.0    0.0    0.00      0.0     0.0
   9   0.0     0.0        0    0.0  0.000     0.0    0.0    0.00      0.0     0.0
  10   0.0   208.9     5686   17.5  0.000     0.0    0.0    5.94    161.6      .5
  11   0.0    43.5      443    1.4   .070     0.0      I       R        R       R
  12   0.0   648.7      201     .4   .120     0.0      I       R        R       R
  13   0.0   400.8    11360   32.3   .025     1.7    0.0    6.02    170.7      .5
  14   0.0   228.0     4525   43.0   .055     3.4    0.0    3.72     73.8      .7
  15   0.0   222.9     3837   39.8   .035     1.9    0.0    4.07     70.1      .7
  16   0.0   179.0     2544   40.6   .060     3.0    0.0    3.59     51.0      .8
  17   0.0   922.2      924   34.3   .060     2.0    0.0   27.71     27.8     1.0
  18   0.0   983.8      696   17.3  0.000     0.0    0.0   59.12     41.8     1.0
  19   0.0  1303.8      737   14.0   .065      .8    0.0  110.27     62.4     1.2
  20   0.0  1238.0      710    9.7  0.000     0.0    0.0  235.58    135.2     1.9
  21   0.0  1321.9      503    4.5  0.000     0.0    0.01006.15    382.6     3.4
  22   0.0    49.5      227    1.4   .080     0.0      I       R        R       R
  23   0.0    11.8      157     .6   .060     0.0      I       R        R       R

CYCLE COMPOSITE    HC     20.712    GRAM/BHP HR
                   CO     78.010    GRAM/BHP HR
                   NO2      .868    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC    1.075      LB/BHP HR
```

ENGINE 2-3

EFFECT OF LABORATORY EGR ON EMISSIONS

GRAPHED RESULTS

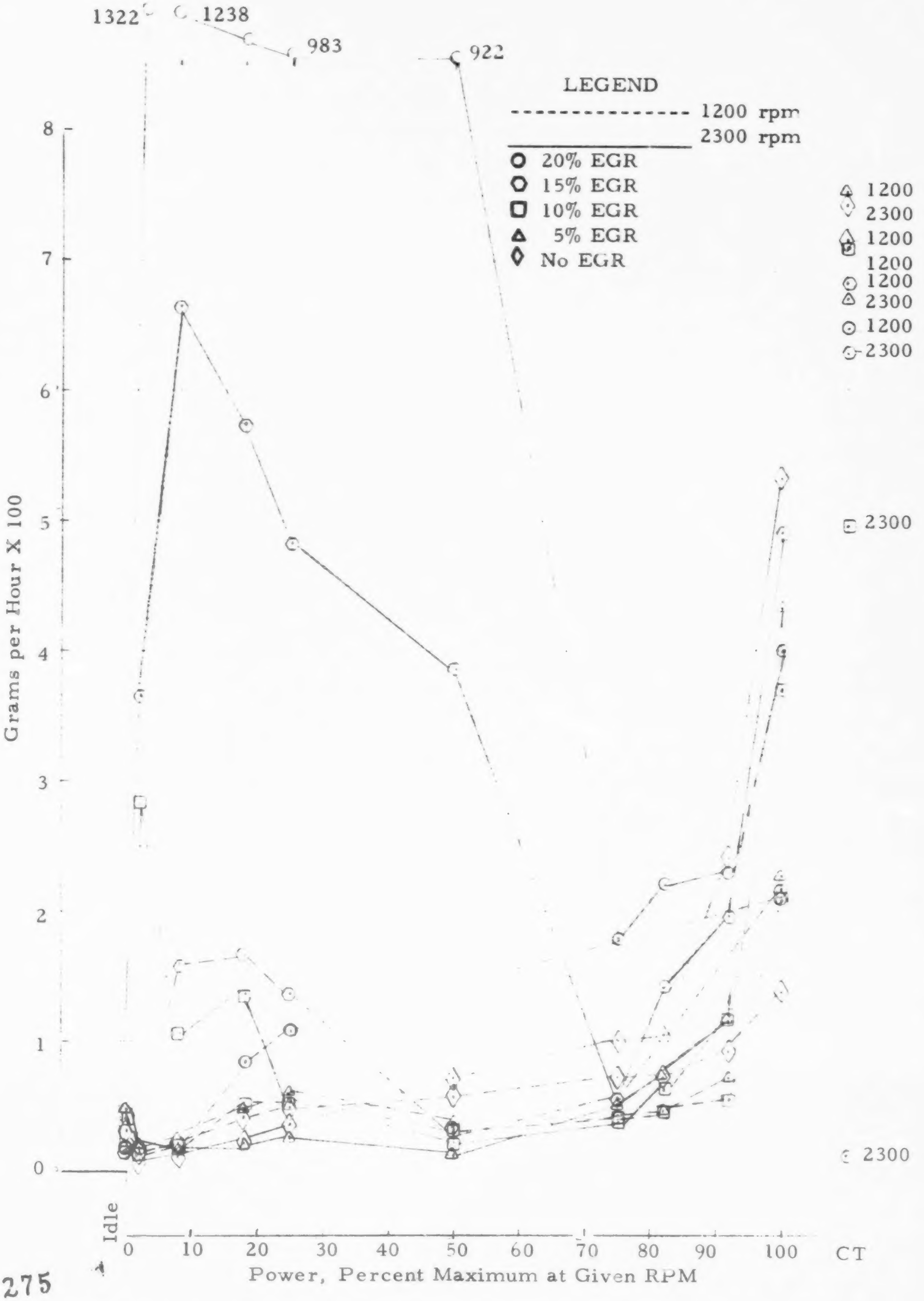


FIGURE L-1. EFFECT OF POWER ON HC EMISSION RATE - LABORATORY EGR, ENGINE 2-3, 23 MODE TEST

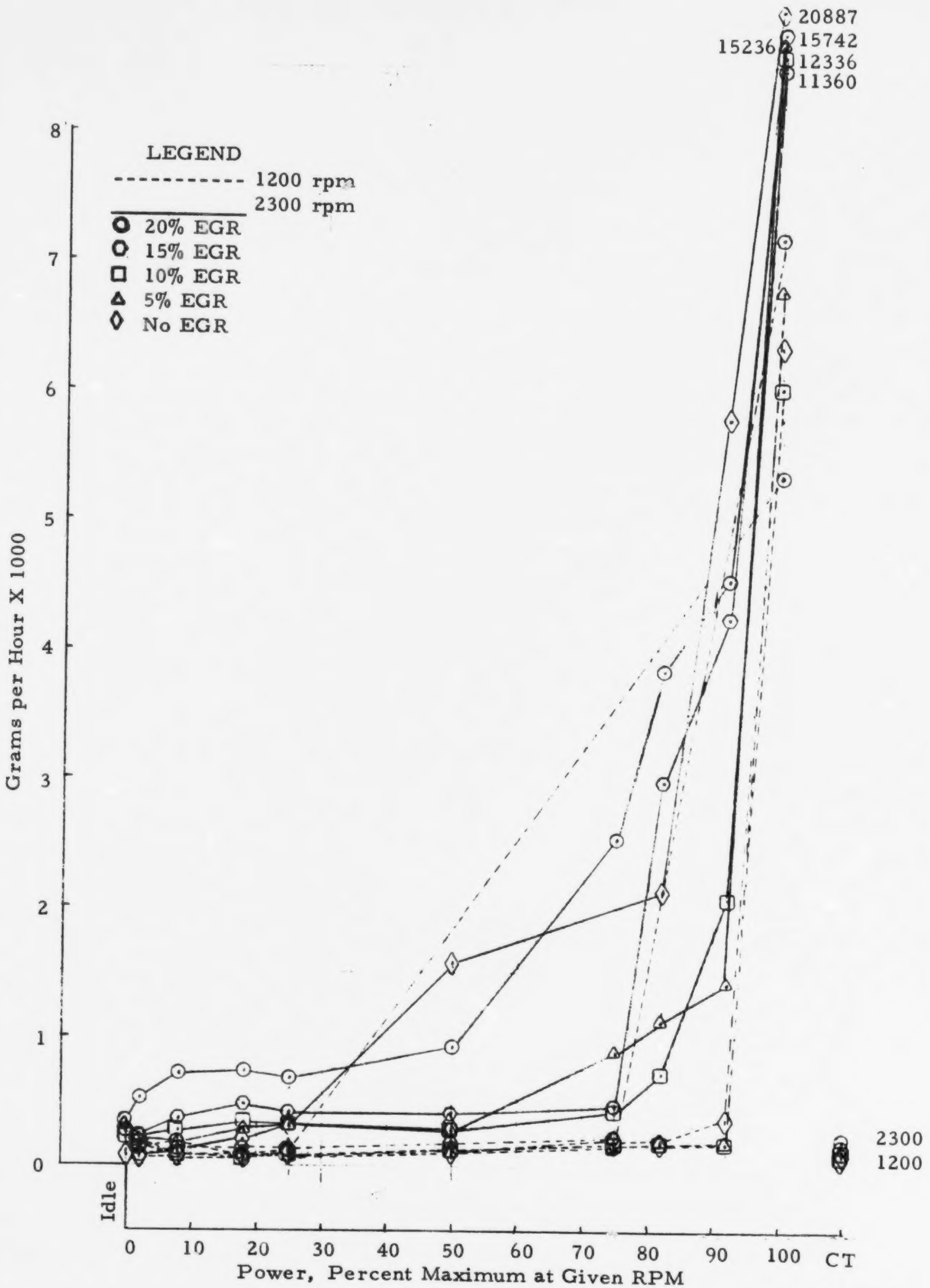


FIGURE L-2. EFFECT OF POWER ON CO EMISSION RATE - LABORATORY EGR, ENGINE 2-3, 23 MODE TEST

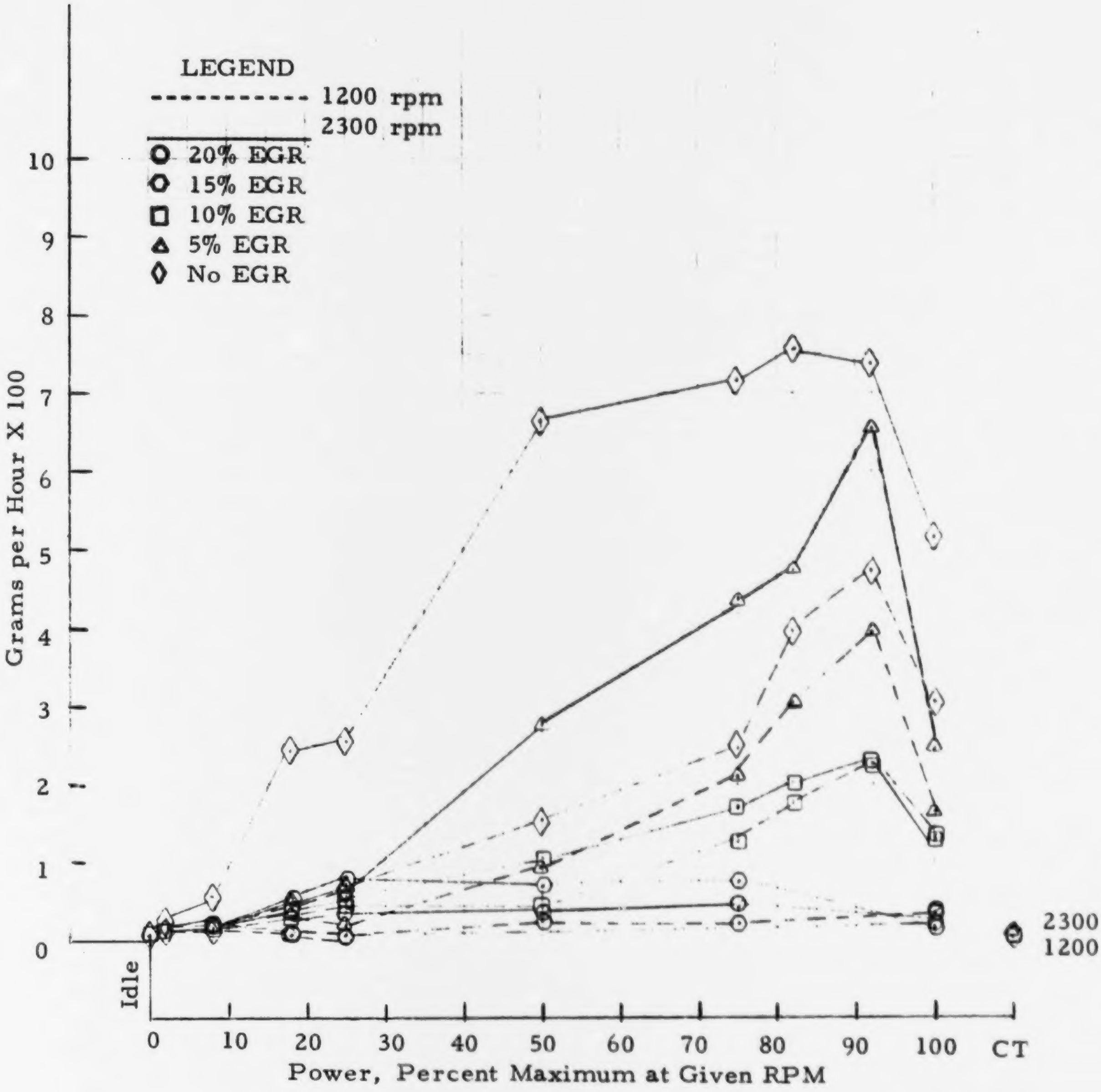


FIGURE L-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE - LABORATORY EGR, ENGINE 2-3, 23 MODE TEST

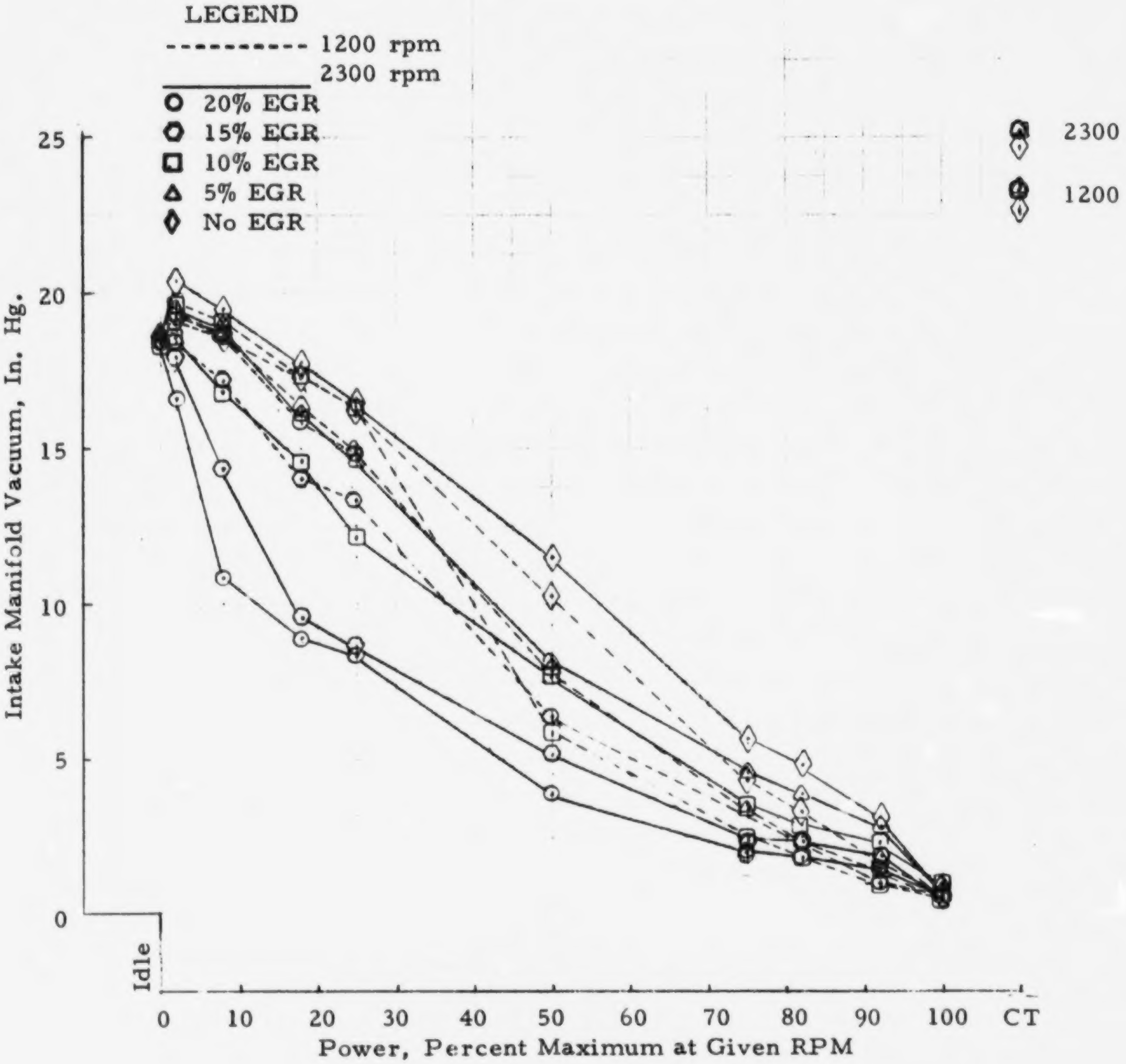


FIGURE L-4. MANIFOLD VACUUM AS A FUNCTION OF POWER - LABORATORY EGR, ENGINE 2-3, 23 MODE TEST

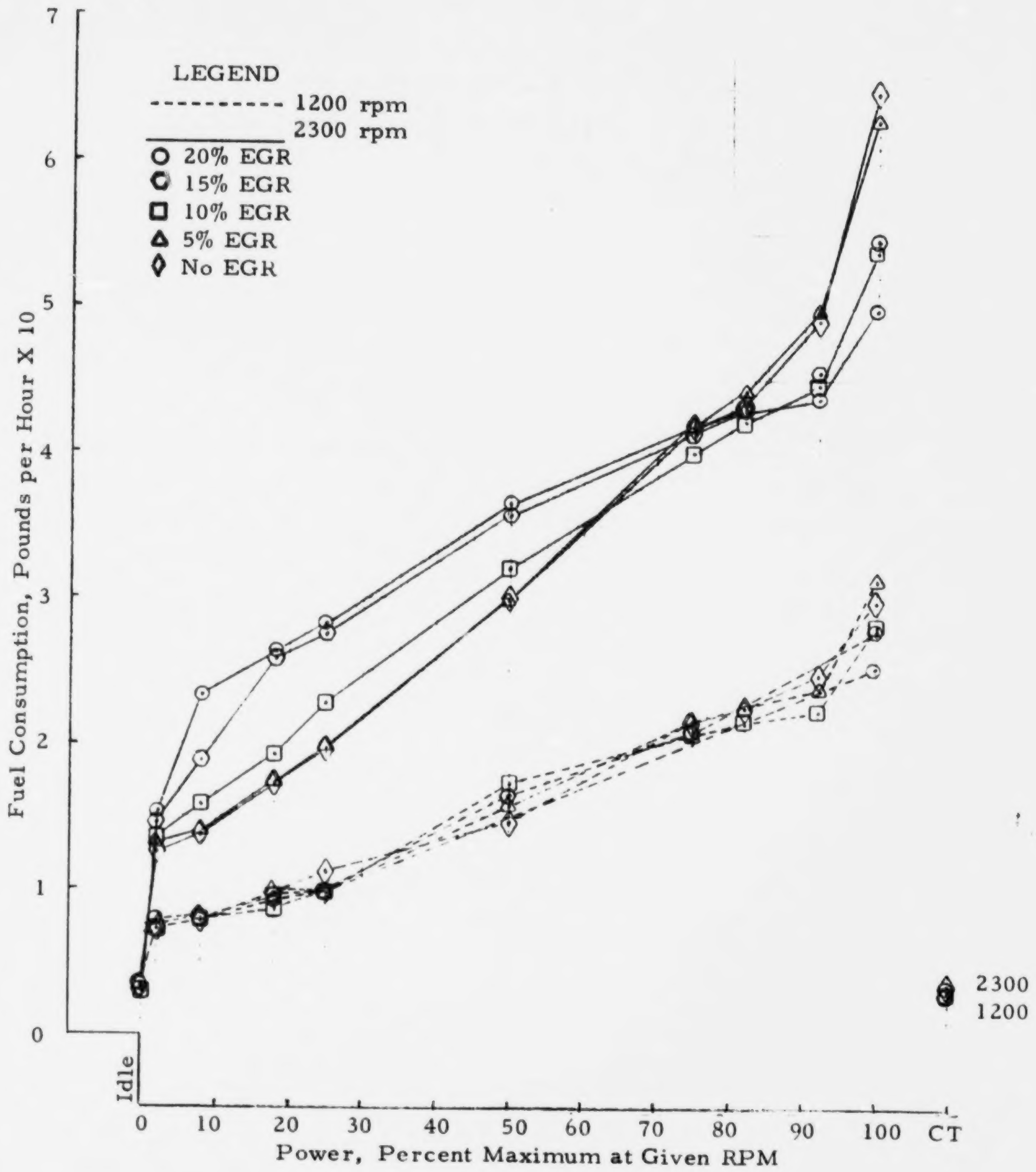


FIGURE L-5. FUEL CONSUMPTION AS A FUNCTION OF POWER - LABORATORY EGR, ENGINE 2-3, 23 MODE TEST

APPENDIX M

ENGINE 2-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 2-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

TABULAR DATA

BEFORE CATALYST

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-14-72 RUN-2          ENG. 2-3  1972 VERSION  8-CATALYTIC W/AIR STD 25 BTBC
-----------------------------------------------------------------------------------------
                   DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED        LOAD    HP    VAC. LB/HR   RATIO    ALDE.     HC        CO       CO2      NO
-----------------------------------------------------------------------------------------
   1   600         0.0     0    19.5   2.7    26.6         0   1053     .150     7.85      27
   2  1200         5.0     1    21.7   5.1    25.5         0   2530     .130     8.14      52
   3  1200        20.0     5    19.3   7.2    24.3         0    985     .100     8.84     215
   4  1200        46.0    11    17.4   8.5    23.7         0   1409     .100     8.93     900
   5  1200        64.0    15    15.5  10.2    22.4         0   1567     .070     9.50    1750
   6  1200       128.0    29     9.7  15.1    20.8         0   1613     .070    10.43    2800
   7  1200       192.0    44     5.5  20.2    17.9         0   1793     .180    12.09    3600
   8  1200       210.0    48     3.8  21.5    17.5         0   1629     .420    12.09    3550
   9  1200       234.0    53     1.9  23.8    17.1         0   1663     .180    12.34    3900
  10  1200       256.0    58      .3  31.3    14.2         0   3303    4.790    10.25    1700
  11   600         0.0     0    20.0   2.7    23.3         0   3893     .210     8.60      44
  12  1200         0.0     0    23.7   2.7    35.6         0  37619     .150     1.66      29
  13  2300       270.0   118      .5  62.5    14.1         0   3253    4.840    10.43    1875
  14  2300       248.0   109     2.2  52.6    14.9         0   1705    3.150    11.60    1325
  15  2300       221.0    97     4.2  45.4    16.0         0   1141    1.410    12.59    2800
  16  2300       203.0    84     5.6  41.7    16.0         0    489    1.480    12.59    2800
  17  2300       135.0    59    10.1  28.7    19.5         0   1051     .130    11.36    3650
  18  2300        68.0    30    15.5  19.3    21.8         0    841     .100     9.93    2025
  19  2300        49.0    21    17.6  16.4    23.6         0   1063     .100     9.03    1050
  20  2300        22.0    10    19.5  13.4    24.9         0   1891     .100     8.60     430
  21  2300         5.0     2    20.5  12.2    25.3         0   2587     .100     8.34     260
  22   600         0.0     0    19.5   2.7    13.7         0   9212     .130     7.56      32
  23  2300         0.0     0    25.1   2.6   133.9         0  14307     .020      .03       2
-----------------------------------------------------------------------------------------
            CALCULATED GRAM/HR           WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.       HC        CO      NO2   FAC.       HP   ALDE.        HC        CO      NO2
-----------------------------------------------------------------------------------------
   1    0.0     16.0       46      1.4   .070      0.0       I         R         R        R
   2    0.0     68.8       71      4.7   .060       .1     0.0     60.22      62.5      4.1
   3    0.0     35.4       73     25.6   .060       .3     0.0      7.75      15.9      5.6
   4    0.0     58.9       85    125.0   .050       .5     0.0      5.61       8.0     11.9
   5    0.0     74.7       67    276.9   .030       .4     0.0      5.11       4.6     18.9
   6    0.0    103.3       91    595.2   .060      1.8     0.0      3.53       3.1     20.4
   7    0.0    132.1      268    881.0  0.000      0.0     0.0      3.01       6.1     20.1
   8    0.0    125.1      652    405.3   .040      1.9     0.0      2.61      13.6     18.9
   9    0.0    141.5      309   1101.8  0.000      0.0     0.0      2.65       5.8     20.6
  10    0.0    304.7     8923    520.5  0.000      0.0     0.0      5.21     152.6      8.9
  11    0.0     51.8       56      2.0   .070      0.0       I         R         R        R
  12    0.0    811.6       65      2.1   .120      0.0       I         R         R        R
  13    0.0    590.9    17761   1130.9   .025      3.0     0.0      5.00     150.2      9.6
  14    0.0    272.7    10181    703.8   .055      6.0     0.0      2.51      93.7      6.5
  15    0.0    166.5     4156   1356.4   .035      3.4     0.0      1.72      42.9     14.0
  16    0.0    132.0     3990   1240.7   .060      5.3     0.0      1.48      44.9     14.0
  17    0.0    118.0      295   1360.1   .060      3.5     0.0      2.00       5.0     23.0
  18    0.0     72.8      175    581.9  0.000      0.0     0.0      2.45       5.9     19.5
  19    0.0     85.5      162    280.4   .065      1.4     0.0      3.98       7.6     13.1
  20    0.0    129.6      138     97.8  0.000      0.0     0.0     13.45      14.4     10.2
  21    0.0    165.1      129     55.1  0.000      0.0     0.0     75.42      58.9     25.2
  22    0.0    131.0       37      1.5   .080      0.0       I         R         R        R
  23    0.0   1122.0       32       .6   .060      0.0       I         R         R        R

CYCLE COMPOSITE    HC       9.383   GRAM/BHP HR
                   CO      53.797   GRAM/BHP HR
                   NO2     13.697   GRAM/BHP HR
                   ALDE     0.000   GRAM/BHP HR
                   BSFC      .567     LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-13-72 RUN-2    ENG. 2-3  1972 VERSION  B-CATALYTIC W/AIR 16 BTDC
-----------------------------------------------------------------------------------
                 DYNA.           MAN. FUEL     A/F              DRY CONCENTRATION
MODE SPEED      LOAD     HP   VAC. LB/HR   RATIO    ALDE.      HC       CO       CO2      NO
-----------------------------------------------------------------------------------
  1    600       0.0      0   19.0    3.3    23.9         0   4094     .130      8.24     26
  2   1200       5.0      1   20.5    5.6    24.8         0    734     .130      8.48     50
  3   1200      21.0      5   19.1    7.0    24.5         0    746     .130      8.60     85
  4   1200      46.0     11   17.6   10.2    24.2         0   1168     .100      8.68    380
  5   1200      64.0     15   16.4   11.1    23.4         0   1289     .070      8.93    840
  6   1200     129.0     29    9.3   15.1    21.1         0   1227     .070     10.25   1625
  7   1200     193.0     44    5.5   20.2    17.9         0   1512     .210     11.84   2750
  8   1200     212.0     48    3.8   21.9    17.5         0   1538     .440     11.92   2800
  9   1200     232.0     53    2.3   23.6    17.2         0   1585     .310     12.22   3100
 10   1200     258.0     59     .3   32.0    14.3         0   2902    4.690     10.25   1525
 11    600       0.0      0   19.5    3.3    24.3         0   1557     .150      8.60     36
 12   1200       0.0      0   23.3    2.8    32.2         0  39880     .280      2.16     12
 13   2300     272.0    119     .5   62.1    13.9         0   3138    4.840     10.43   1500
 14   2300     250.0    109    3.0   47.5    15.5         0   1177    1.870     12.34   2000
 15   2300     223.0     98    5.0   44.1    15.9         0    836    1.380     12.71   217
 16   2300     204.0     89    6.2   41.0    16.1         0    733    1.120     12.71   2250
 17   2300     136.0     60   10.1   28.0    19.5         0    840     .180     11.24   2650
 18   2300      68.0     30   16.0   18.8    21.9         0    738     .130      9.93   1475
 19   2300      49.0     21   17.5   16.9    23.4         0    613     .100      9.14    790
 20   2300      22.0     10   19.8   12.9    25.4         0    443     .100      8.48    260
 21   2300       5.0      2   21.2    9.4    26.2         0    754     .100      8.24    127
 22    600       0.0      0   19.0    3.3    26.1         0    334     .100      8.34     27
 23   2300       0.0      0   24.9    2.8    44.2         0  44533     .050       .03      6
-----------------------------------------------------------------------------------
            CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2  FAC.       HP   ALDE.      HC       CO     NO2
-----------------------------------------------------------------------------------
  1    0.0     69.0       44      1.5  .070      0.0       I        R        R       R
  2    0.0     21.4       77      4.8  .060       .1     0.0    18.73     67.0     4.2
  3    0.0     27.0       95     10.2  .060       .3     0.0     5.62     19.8     2.1
  4    0.0     60.7      105     65.5  .050       .5     0.0     5.77     10.0     6.2
  5    0.0     71.0       78    153.7  .030       .4     0.0     4.86      5.3    10.5
  6    0.0     80.6       93    354.3  .060      1.8     0.0     2.73      3.2    12.0
  7    0.0    113.7      319    686.7 0.000      0.0     0.0     2.58      7.2    15.6
  8    0.0    122.0      705    737.6  .040      1.9     0.0     2.52     14.6    15.2
  9    0.0    134.0      529    870.2 0.000      0.0     0.0     2.53     10.0    16.4
 10    0.0    276.2     9015    481.8 0.000      0.0     0.0     4.69    152.9     8.2
 11    0.0     26.0       51      2.0  .070      0.0       I        R        R       R
 12    0.0    788.0      112       .8  .120      0.0       I        R        R       R
 13    0.0    567.3    17672    900.2  .025      3.0     0.0     4.76    148.4     7.6
 14    0.0    177.1     5686    999.6  .055      6.0     0.0     1.62     51.9     9.1
 15    0.0    117.9     3931   1018.2  .035      3.4     0.0     1.21     40.2    10.4
 16    0.0     98.1     3026    999.2  .060      5.4     0.0     1.10     33.9    11.2
 17    0.0     92.7      401    970.3  .060      3.6     0.0     1.56      6.7    16.3
 18    0.0     62.2      221    412.7 0.000      0.0     0.0     2.09      7.4    13.9
 19    0.0     50.5      166    215.9  .065      1.4     0.0     2.35      7.7    10.1
 20    0.0     29.9      137     58.3 0.000      0.0     0.0     3.10     14.2     6.1
 21    0.0     38.0      102     21.4 0.000      0.0     0.0    17.37     46.5     9.8
 22    0.0      5.9       35      1.6  .080      0.0       I        R        R       R
 23    0.0   1247.7       28       .6  .060      0.0       I        R        R       R

CYCLE COMPOSITE     HC       8.537    GRAM/BHP HR
                    CO      42.661    GRAM/BHP HR
                    NO2     10.995    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .560      LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
    7-12-72 RUN 1   ENG. 2-3, 1972 VERSION, B-CATALYTIC W/AIR STD
--------------------------------------------------------------------------------------
                DYNA.         MAN.  FUEL     A/F                 DRY CONCENTRATION
MODE SPEED       LOAD   HP    VAC. LB/HR   RATIO   ALDE.     HC      CO      CO2     NO
--------------------------------------------------------------------------------------
   1   600        0.0    0    18.5   3.7    23.7       0    896    .180     9.14     30
   2  1200        5.0    1    19.5   7.0    25.1       0    308    .100     8.75     43
   3  1200       19.0    4    18.4   7.7    24.8       0    611    .100     8.75    102
   4  1200       42.0   10    17.5   8.3    24.2       0    802    .100     8.93    220
   5  1200       59.0   13    15.7  10.1    23.1       0    979    .100     9.37    460
   6  1200      117.0   27     8.8  16.0    20.9       0    737    .100    10.66    770
   7  1200      176.0   40     4.9  20.6    18.5       0    691    .180    12.22   1662
   8  1200      192.0   44     3.6  22.1    18.2       0    641    .280    12.22   1750
   9  1200      215.0   49     2.0  23.8    17.4       0    868    .210    12.71   2212
  10  1200      234.0   53      .3  31.5    13.9       0   1813   4.160    11.01   1125
  11   600        0.0    0    18.9   3.7    22.4       0    638    .210     9.64     50
  12  1200        0.0    0    23.0   3.7    30.0       0  37979    .250     2.61     15
  13  2300      263.0  115      .5  63.8    13.8       0   2688   5.140    10.43   1025
  14  2300      241.0  106     2.8  51.4    15.2       0    602   2.050    12.71    938
  15  2300      216.0   95     4.8  43.6    16.0       0    273   1.090    12.94   1525
  16  2300      197.0   86     6.2  42.0    16.3       0    214    .640    13.18   1575
  17  2300      132.0   58     9.3  28.8    19.6       0    256    .150    11.60   1462
  18  2300       66.0   29    15.8  19.8    22.3       0    443    .150     9.93    863
  19  2300       47.0   21    17.2  17.4    23.4       0    384    .100     9.64    520
  20  2300       21.0    9    19.4  13.5    25.7       0    292    .100     8.60    200
  21  2300        5.0    2    21.0  11.3    26.6       0    223    .100     8.34     94
  22   600        0.0    0    18.5   3.7    24.0       0    854    .100     9.14     32
  23  2300        0.0    0    25.0   3.5    43.8       0  45046    .050      .06      4
--------------------------------------------------------------------------------------
            CALCULATED GRAM/HR            WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO     NO2    FAC.      HP  ALDE.      HC      CO     NO2
--------------------------------------------------------------------------------------
   1   0.0    15.8      64     1.8    .070     0.0      I       R       R       R
   2   0.0    11.0      72     5.0    .060      .1    0.0    9.62    63.0     4.4
   3   0.0    24.1      80    13.4    .060      .3    0.0    5.55    18.3     3.1
   4   0.0    33.2      84    30.3    .050      .5    0.0    3.46     8.7     3.2
   5   0.0    47.1      97    73.5    .030      .4    0.0    3.49     7.2     5.5
   6   0.0    49.4     135   171.5    .060     1.6    0.0    1.85     5.1     6.4
   7   0.0    51.9     273   414.2   0.000     0.0    0.0    1.29     6.8    10.3
   8   0.0    51.2     451   463.6    .040     1.8    0.0    1.17    10.3    10.6
   9   0.0    72.0     352   609.7   0.000     0.0    0.0    1.47     7.2    12.4
  10   0.0   168.9    7826   347.9   0.000     0.0    0.0    3.16   146.4     6.5
  11   0.0    10.7      71     2.8    .070     0.0      I       R       R       R
  12   0.0   949.6     126     1.3    .120     0.0      I       R       R       R
  13   0.0   491.4   18980   622.1    .025     2.9    0.0    4.27   164.8     5.4
  14   0.0    94.8    6516   489.8    .055     5.8    0.0     .90    61.7     4.6
  15   0.0    38.5    3098   712.3    .035     3.3    0.0     .41    32.7     7.5
  16   0.0    29.5    1780   719.9    .060     5.2    0.0     .34    20.6     8.3
  17   0.0    28.5     337   539.4    .060     3.5    0.0     .49     5.8     9.3
  18   0.0    39.2     268   253.5   0.000     0.0    0.0    1.36     9.3     8.8
  19   0.0    31.0     163   139.5    .065     1.3    0.0    1.51     7.9     6.8
  20   0.0    20.5     142    46.6   0.000     0.0    0.0    2.23    15.4     5.1
  21   0.0    13.6     123    18.9   0.000     0.0    0.0    6.19    56.1     8.6
  22   0.0    15.2      36     1.9    .080     0.0      I       R       R       R
  23   0.0  1563.0      35      .4    .060     0.0      I       R       R       R

CYCLE COMPOSITE    HC       9.241    GRAM/BHP HR
                   CO      43.347    GRAM/BHP HR
                   NO2      7.019    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .612      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-12-72 RUN-2        ENG. 2-3, 1972 VERSION  B-CATALYTIC W/AIR STD
------------------------------------------------------------------------------------
              DYNA.         MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO    ALDE.     HC       CO       CO2     NO
------------------------------------------------------------------------------------
  1    600     0.0     0   18.5   4.0   23.7        0   1259     .100      9.14     26
  2   1200     5.0     1   19.6   7.1   25.2        0    405     .100      8.60     39
  3   1200    19.0     4   18.8   7.4   24.8        0    541     .070      8.84     71
  4   1200    42.0    10   16.8   8.3   23.7        0    908     .070      9.37    245
  5   1200    59.0    13   15.7  10.0   22.7        0   1027     .070      9.93    505
  6   1200   117.0    27    9.8  15.1   20.9        0    865     .070     11.01    770
  7   1200   176.0    40    4.8  21.4   18.3        0    785     .150     12.94   1813
  8   1200   192.0    44    3.8  22.0   17.7        0    727     .280     12.47   1750
  9   1200   215.0    49    2.4  23.1   17.5        0    838     .210     12.47   2162
 10   1200   234.0    53     .3  31.5   15.0        0   1970    4.350     11.36   1112
 11    600     0.0     0   19.0   3.4   22.5        0    668     .180     10.09     38
 12   1200     0.0     0   23.0   3.6   31.2        0  38468     .150      2.64     11
 13   2300   263.0   115     .5  63.0   17.8        0   2886    5.030     10.43   1050
 14   2300   241.0   106    2.7  51.3   15.2        0    600    2.110     12.22    913
 15   2300   216.0    95    4.7  45.4   16.1        0    300    1.120     13.06   1625
 16   2300   197.0    86    6.0  41.2   16.4        0    210     .670     13.06   1725
 17   2300   132.0    58   10.0  28.8   20.0        0    304     .100     11.48   1550
 18   2300    66.0    29   15.6  18.6   22.0        0   2672     .100      9.93    975
 19   2300    47.0    21   17.5  16.1   23.6        0    397     .100      9.37    530
 20   2300    21.0     9   19.2  13.9   25.3        0    303     .100      8.68    240
 21   2300     5.0     2   21.0  11.2   26.9        0    217     .070      8.34     98
 22    600     0.0     0   18.5   3.9   25.2        0   1016     .100      8.60     31
 23   2300     0.0     0   24.9   3.5   46.3        0  41600     .100       .16      7
------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2  FAC.       HP   ALDE.      HC       CO    NO2
------------------------------------------------------------------------------------
  1    0.0    24.1      39      1.7  .070      0.0       I       R        R      R
  2    0.0    15.0      75      4.8  .060       .1     0.0   13.12     65.4    4.2
  3    0.0    20.2      53      8.8  .060       .3     0.0    4.66     12.2    2.0
  4    0.0    35.8      56     32.1  .050       .5     0.0    3.73      5.8    3.3
  5    0.0    46.2      64     75.4  .030       .4     0.0    3.42      4.7    5.6
  6    0.0    53.0      87    156.6  .060      1.6     0.0    1.98      3.2    5.9
  7    0.0    57.7     223    442.5 0.000      0.0     0.0    1.44      5.5   11.0
  8    0.0    56.6     440    452.2  .040      1.8     0.0    1.29     10.0   10.3
  9    0.0    68.8     348    589.6 0.000      0.0     0.0    1.40      7.1   12.0
 10    0.0   176.9    7893    331.8 0.000      0.0     0.0    3.31    147.6    6.2
 11    0.0    11.5      63      2.2  .070      0.0       I       R        R      R
 12    0.0   946.5      75       .9  .120      0.0       I       R        R      R
 13    0.0   523.5   18431    532.4  .025      2.9     0.0    4.55    160.0    5.5
 14    0.0    97.1    6892    489.9  .055      5.8     0.0     .92     65.3    4.6
 15    0.0    43.5    3281    782.4  .035      3.3     0.0     .46     34.7    8.3
 16    0.0    28.5    1840    778.7  .060      5.2     0.0     .33     21.3    9.0
 17    0.0    34.3     228    579.8  .060      3.5     0.0     .59      3.9   10.0
 18    0.0   218.7     165    264.9 0.000      0.0     0.0    7.57      5.7    9.2
 19    0.0    30.4     155    134.8  .065      1.3     0.0    1.48      7.5    6.5
 20    0.0    21.7     145     57.1 0.000      0.0     0.0    2.36     15.8    6.2
 21    0.0    13.1      85     19.6 0.000      0.0     0.0    5.98     39.0    8.9
 22    0.0    20.5      41      2.1  .080      0.0       I       R        R      R
 23    0.0  1507.0      73       .8  .060      0.0       I       R        R      R

CYCLE COMPOSITE     HC       9.211   GRAM/BHP HR
                    CO      43.227   GRAM/BHP HR
                    NO2      7.276   GRAM/BHP HR
                    ALDE     0.000   GRAM/BHP HR
                    BSFC      .607     LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-14-72 RUN-3 ENG.2-3 72-VER. B-CATA. W/AIR STD. J.-0.075 R.-0.038
------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO    ALDE.    HC       CO      CO2     NO
------------------------------------------------------------------------------
   1   600     0.0     0  18.0   3.9   22.7        0    926    .150    9.50    33
   2  1200     5.0     1  19.6   7.1   23.4        0    348    .100    9.37    59
   3  1200    18.0     4  18.9   7.9   22.7        0    332    .130    9.50    98
   4  1200    41.0     9  17.8   9.0   21.8        0    711    .150    9.93   400
   5  1200    58.0    13  16.7   9.9   20.7        0    869    .280   10.55   590
   6  1200   115.0    26  11.8  14.3   19.2        0   1115    .280   11.01  1400
   7  1200   173.0    40   6.0  21.9   16.1        0    859   1.120   12.94   870
   8  1200   189.0    43  44.2  34.4   19.6        0    769   1.270   12.82   450
   9  1200   212.0    48   2.8  25.6   15.7        0    780   1.520   12.59   975
  10  1200   230.0    53    .3  32.3   13.8        0   1855   4.930   10.78   620
  11   600     0.0     0  18.5   3.9   21.3        0    482    .280   10.09    39
  12  1200     0.0     0  22.5   3.7   28.8        0  30540    .250    3.56     8
  13  2300   262.0   115    .5  64.9   13.7        0   2521   5.240   10.55   800
  14  2300   239.0   105   2.1  58.0   13.8        0   1079   4.540   11.48   300
  15  2300   213.0    93   4.5  47.1   14.4        0    538   3.060   12.59   600
  16  2300   195.0    85   5.8  47.0   14.6        0    303   2.360   13.18   640
  17  2300   130.0    57  11.2  30.3   17.6        0    274    .310   12.47  1825
  18  2300    65.0    28  16.4  20.3   20.1        0    282    .280   11.01  1150
  19  2300    47.0    21  17.5  18.3   20.6        0    320    .250   10.89   890
  20  2300    21.0     9  19.8  13.9   22.9        0    180    .180    9.78   290
  21  2300     5.0     2  21.0  12.7   23.3        0    146    .150    9.37   205
  22   600     0.0     0  18.0   3.9   23.1        0    556    .150    9.50    41
  23  2300     0.0     0  24.4   3.9   38.1        0  49150    .070     .26     4
------------------------------------------------------------------------------
           CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2  FAC.      HP  ALDE.      HC       CO     NO2
------------------------------------------------------------------------------
   1   0.0    17.0       56     2.0  .070     0.0      I       R        R       R
   2   0.0    11.8       68     6.6  .060      .1    0.0   10.31     59.8     5.8
   3   0.0    12.3       97    12.0  .060      .2    0.0    2.99     23.6     2.9
   4   0.0    28.5      121    53.2  .050      .5    0.0    3.04     13.0     5.7
   5   0.0    35.8      233    80.6  .030      .4    0.0    2.70     17.6     6.1
   6   0.0    63.4      322   264.2  .060     1.6    0.0    2.41     12.2    10.1
   7   0.0    60.2     1585   202.4 0.000     0.0    0.0    1.52     40.1     5.1
   8   0.0    84.7     2827   164.6  .040     1.7    0.0    1.96     65.5     3.8
   9   0.0    63.7     2509   264.5 0.000     0.0    0.0    1.32     51.8     5.5
  10   0.0   171.0     9176   189.7 0.000     0.0    0.0    3.25    174.6     3.6
  11   0.0     8.2       96     2.2  .070     0.0      I       R        R       R
  12   0.0   748.7      124      .6  .120     0.0      I       R        R       R
  13   0.0   462.8    19427   487.5  .025     2.9    0.0    4.03    169.3     4.2
  14   0.0   176.1    14960   162.5  .055     5.8    0.0    1.68    142.9     1.6
  15   0.0    73.2     8408   270.9  .035     3.3    0.0     .78     90.1     2.9
  16   0.0    41.5     6525   290.8  .060     5.1    0.0     .49     76.4     3.4
  17   0.0    29.4      672   650.4  .060     3.4    0.0     .52     11.8    11.4
  18   0.0    23.0      461   311.2 0.000     0.0    0.0     .81     16.2    10.9
  19   0.0    23.8      376   219.8  .065     1.3    0.0    1.16     18.2    10.7
  20   0.0    11.4      230    60.8 0.000     0.0    0.0    1.24     25.0     6.6
  21   0.0     8.8      183    41.0 0.000     0.0    0.0    4.01     83.4    18.7
  22   0.0    10.2       56     2.5  .080     0.0      I       R        R       R
  23   0.0  1666.2       48      .5  .060     0.0      I       R        R       R

CYCLE COMPOSITE     HC       8.881    GRAM/BHP HR
                    CO      85.596    GRAM/BHP HR
                    NO2      4.975    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .675      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-13-72 RUN 3   ENG. 2-3  1972 VERSION  B-CATALYTIC W/AIR 4 ATDC
---------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO   ALDE.    HC       CO       CO2     NO
---------------------------------------------------------------------------------
  1   600      0.0     0  16.5    4.6   22.4       0  1002     .130     9.50     40
  2  1200      4.0     1  18.7    7.6   24.8       0   370     .100     8.60     50
  3  1200     16.0     4  18.2    7.8   24.9       0   454     .100     8.60     62
  4  1200     37.0     8  16.4    9.8   23.6       0   581     .100     9.14    145
  5  1200     51.0    12  15.4   10.0   23.1       0   646     .100     9.25    215
  6  1200    102.0    23   7.8   17.6   19.8       0   343     .070    11.36    605
  7  1200    153.0    35   4.1   22.3   17.7       0   306     .130    12.22   1137
  8  1200    167.0    38   3.0   22.9   17.7       0   323     .150    12.09   1275
  9  1200    188.0    43   1.8   24.4   17.1       0   423     .180    12.71   1587
 10  1200    204.0    47    .3   31.5   14.4       0   874    3.520    11.84    800
 11   600      0.0     0  17.0    4.2   21.8       0   464     .180     9.64     48
 12  1200      0.0     0  22.0    4.4   57.0       0   384     .280     3.13     10
 13  2300    236.0   103    .5   64.3   13.7       0  2012    4.790    10.66    705
 14  2300    217.0    95   2.4   53.6   14.8       0   290    1.730    13.18    560
 15  2300    194.0    85   4.2   46.0   16.0       0   158     .490    13.18   1000
 16  2300    177.0    78   5.5   42.7   16.1       0   148     .470    13.48    950
 17  2300    118.0    52   9.3   30.8   19.4       0   166     .100    11.48    925
 18  2300     59.0    26  15.5   18.5   22.4       0   278     .100     9.78    505
 19  2300     42.0    18  16.9   18.0   23.2       0   232     .100     9.37    315
 20  2300     19.0     8  18.9   14.0   21.5       0   192     .100     8.75    150
 21  2300      5.0     2  20.2   12.2   26.2       0   145     .100     8.24     84
 22   600      0.0     0  16.5    4.5   22.9       0  1023     .130     9.37     43
 23  2300      0.0     0  24.1    4.6   34.9       0 56083     .070      .09      5
---------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
---------------------------------------------------------------------------------
  1    0.0    21.3       56     2.8  .070      0.0      I       R        R       R
  2    0.0    14.5       79     6.5  .060       .1    0.0   15.89     86.7     7.1
  3    0.0    18.5       82     8.4  .060       .2    0.0    5.06     22.5     2.3
  4    0.0    27.7       96    23.0  .050       .4    0.0    3.28     11.4     2.7
  5    0.0    31.1       97    34.3  .030       .3    0.0    2.66      8.3     2.9
  6    0.0    23.9       98   139.9  .060      1.4    0.0    1.02      4.2     6.0
  7    0.0    25.0      214   308.3 0.000      0.0    0.0     .72      6.1     8.8
  8    0.0    27.3      256   357.7  .040      1.5    0.0     .71      6.7     9.4
  9    0.0    36.2      312   451.8 0.000      0.0    0.0     .84      7.3    10.5
 10    0.0    80.8     6573   245.5 0.000      0.0    0.0    1.73    141.0     5.3
 11    0.0     8.9       70     3.1  .070      0.0      I       R        R       R
 12    0.0    22.1      325     1.8  .120      0.0      I       R        R       R
 13    0.0   375.0    18040   436.4  .025      2.6    0.0    3.63    174.5     4.2
 14    0.0    47.2     5687   302.6  .055      5.2    0.0     .50     59.8     3.2
 15    0.0    24.1     1510   506.6  .035      3.0    0.0     .28     17.8     6.0
 16    0.0    20.5     1316   437.0  .060      4.7    0.0     .26     17.0     5.6
 17    0.0    20.0      244   370.2  .060      3.1    0.0     .39      4.7     7.2
 18    0.0    23.6      171   142.0 0.000      0.0    0.0     .91      6.6     5.5
 19    0.0    20.0      174    90.1  .065      1.2    0.0    1.09      9.5     4.9
 20    0.0    13.7      144    35.6 0.000      0.0    0.0    1.65     17.3     4.3
 21    0.0     9.6      133    18.4 0.000      0.0    0.0    4.39     61.0     8.4
 22    0.0    21.9       56     3.0  .080      0.0      I       R        R       R
 23    0.0  2006.6       51      .6  .060      0.0      I       R        R       R

CYCLE COMPOSITE      HC       6.341    GRAM/BHP HR
                     CO      42.632    GRAM/BHP HR
                     NO2      5.327    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .726      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-14-72 RUN-2   ENG. 2-3  1972 VERSION  B-CATALYTIC W/O AIR STD
----------------------------------------------------------------------------
                DYNA.          MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED      LOAD    HP  VAC. LB/HR   RATIO    ALDE.    HC       CO      CO2     NO
----------------------------------------------------------------------------
  1    600       0.0     0  18.0    3.6    15.3        0  3271     .770   13.06     46
  2   1200       5.0     1  19.2    7.3    16.3        0   462     .130   13.48     70
  3   1200      18.0     4  18.7    7.4    16.4        0   376     .100   13.18     85
  4   1200      41.0     9  17.0    9.6    16.7        0   963     .100   12.82    340
  5   1200      58.0    13  15.1   10.2    16.7        0  1143     .100   12.94    630
  6   1200     115.0    26   8.4   16.6    16.2        0   764     .100   13.33   1125
  7   1200     173.0    40   4.7   20.7    15.3        0  1179     .350   14.05   1912
  8   1200     189.0    43   3.6   21.3    15.2        0  1086     .470   13.77   2112
  9   1200     212.0    48   2.2   23.6    15.0        0  1441     .390   14.18   2450
 10   1200     230.0    53    .3   31.7    12.9        0  2656    5.040   11.60   1175
 11    600       0.0     0  18.5    3.6    13.6        0  4065    4.070   11.60     56
 12   1200       0.0     0  22.5    4.5    14.7        0 35735    2.080    8.68     17
 13   2300     260.0   114    .5   62.1    13.2        0  2994    4.790   11.60   1475
 14   2300     239.0   105   3.0   47.5    14.4        0  1280    2.110   13.33   1700
 15   2300     213.0    93   4.8   44.6    14.4        0  1408    2.180   13.48   1712
 16   2300     195.0    85   6.0   41.9    14.6        0  1417    1.840   13.63   1837
 17   2300     130.0    57   9.8   29.5    16.7        0   273     .100   13.33   1775
 18   2300      65.0    28  15.4   26.6    17.0        0   337     .100   13.06   1200
 19   2300      47.0    21  16.8   17.0    17.1        0   269     .100   13.06    770
 20   2300      21.0     4  19.1   13.3    17.2        0   163     .070   13.18    315
 21   2300       5.0     2  20.5   11.4    17.2        0    93     .070   13.18    176
 22    600       0.0     0  19.0    3.6    16.3        0  1807     .350   13.63     53
 23   2300       0.0     0  24.5    3.6    18.8        0 38343     .280    7.56     11
----------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO     NO2  FAC.      HP  ALDE.     HC      CO     NO2
----------------------------------------------------------------------------
  1   0.0    38.1     181     1.8  .070     0.0      I       R       R       R
  2   0.0    11.2      64     5.7  .060      .1    0.0    9.81    55.8     5.0
  3   0.0     9.5      51     7.1  .060      .2    0.0    2.30    12.3     1.7
  4   0.0    32.2      68    37.8  .050      .5    0.0    3.44     7.2     4.0
  5   0.0    40.3      71    73.7  .030      .4    0.0    3.04     5.4     5.6
  6   0.0    42.5     112   207.7  .060     1.6    0.0    1.62     4.3     7.9
  7   0.0    76.1     456   409.4 0.000     0.0    0.0    1.92    11.5    10.4
  8   0.0    73.1     639   471.8  .040     1.7    0.0    1.69    14.8    10.9
  9   0.0   104.8     573   591.3 0.000     0.0    0.0    2.16    11.8    12.2
 10   0.0   224.7    8785   330.1 0.000     0.0    0.0    4.28   167.2     6.3
 11   0.0    41.5     840     1.9  .070     0.0      I       R       R       R
 12   0.0   506.6     596      .8  .120     0.0      I       R       R       R
 13   0.0   505.2   16326   826.3  .025     2.8    0.0    4.44   143.4     7.3
 14   0.0   177.2    5901   781.5  .055     5.8    0.0    1.69    56.4     7.5
 15   0.0   180.3    5638   727.9  .035     3.3    0.0    1.93    60.4     7.8
 16   0.0   172.7    4529   743.4  .060     5.1    0.0    2.02    53.0     8.7
 17   0.0    27.1     201   585.6  .060     3.4    0.0     .48     3.5    10.3
 18   0.0    30.7     185   363.9 0.000     0.0    0.0    1.08     6.5    12.8
 19   0.0    15.8     118   149.8  .065     1.3    0.0     .77     5.7     7.3
 20   0.0     7.4      64    47.5 0.000     0.0    0.0     .80     7.0     5.2
 21   0.0     3.6      55    22.9 0.000     0.0    0.0    1.66    25.3    10.5
 22   0.0    21.1      82     2.1  .080     0.0      I       R       R       R
 23   0.0   536.3      79      .5  .060     0.0      I       R       R       R

CYCLE COMPOSITE    HC      5.775    GRAM/BHP HR
                   CO     54.155    GRAM/BHP HR
                   NO2     8.210    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .617      LB/BHP HR
```

ENGINE 2-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

TABULAR DATA

AFTER CATALYST

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-14-72 RUN-2   ENG. 2-3  1972 VERSION  A-CATALYTIC W/AIR STD 25 BTDC
------------------------------------------------------------------------------------
                  DYNA.         MAN.  FUEL    A/F              DRY CONCENTRATION
MODE SPEED        LOAD    HP    VAC. LB/HR   RATIO    ALDE.     HC       CO      CO2     NO
------------------------------------------------------------------------------------
  1   600          0.0     0   19.5    2.7    27.4
  2  1200          5.0     1   21.7    5.1    14.8       0      220     .070     7.85     26
  3  1200         20.0     5   19.3    7.2    25.0       0       66     .100     7.94     51
  4  1200         46.0    11   17.4    8.5    24.1       0      246     .070     8.60    214
  5  1200         64.0    15   15.5   10.2    22.9       0      357     .100     8.84    900
  6  1200        128.0    29    9.7   15.1    21.0       0      370     .070     9.37   1737
  7  1200        192.0    44    5.5   20.2    18.2       0      398     .070    10.43   2800
  8  1200        210.0    48    3.8   21.5    18.1       0      445     .050    12.09   3400
  9  1200        234.0    53    1.9   23.8    17.6       0      450     .050    11.92   3500
 10  1200        256.0    58     .3   31.3    14.5       0      613     .050    12.34   3600
 11   600          0.0     0   20.0    2.7    26.2       0     2166    2.780    12.34   1600
 12  1200          0.0     0   23.7    2.7    54.9       0     1344     .050     8.04     68
 13  2300        270.0   118     .5   62.5    13.8       0       62     .050     3.62     25
 14  2300        248.0   109    2.2   52.6    15.2       0     1553    4.020    12.22   1525
 15  2300        221.0    97    4.2   45.4    16.5       0      540    1.120    13.77   1500
 16  2300        203.0    89    5.6   41.7    16.8       0      217     .150    13.63   2900
 17  2300        135.0    59   10.1   28.7    20.1       0      219     .100    13.18   2900
 18  2300         68.0    30   15.5   19.3    22.5       0      435     .050    11.01   3550
 19  2300         49.0    21   17.6   16.4    23.8       0      270     .050     9.78   1950
 20  2300         22.0    10   19.5   13.4    25.2       0      304     .050     9.14   1075
 21  2300          5.0     2   20.5   12.2    25.8       0      284     .050     8.60    450
 22   600          0.0     0   19.5    2.7    27.5       0      728     .050     8.43    250
 23  2300          0.0     0   25.1    2.6    85.9       0     1501     .020     7.75     31
                                                         0       63     .020     2.37      2
------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2   FAC.       HP   ALDE.       HC       CO     NO2
------------------------------------------------------------------------------------
  1   0.0      3.4       22     1.3   .070      0.0      I         R        R       R
  2   0.0      1.9       58     4.9   .060       .1    0.0      1.66     50.9     4.3
  3   0.0      9.2       53    26.5   .060       .3    0.0      2.01     11.6     5.8
  4   0.0     15.3       86   127.7   .050       .5    0.0      1.45      8.2    12.2
  5   0.0     18.1       69   282.1   .030       .4    0.0      1.24      4.7    19.3
  6   0.0     25.8       92   602.1   .060      1.8    0.0       .88      3.1    20.6
  7   0.0     33.5       76   850.1  0.000      0.0    0.0       .76      1.7    19.4
  8   0.0     36.4       82   941.4   .040      1.9    0.0       .76      1.7    19.6
  9   0.0     53.2       88  1036.3  0.000      0.0    0.0       .99      1.6    19.4
 10   0.0    200.2     5190   491.0  0.000      0.0    0.0      3.42     88.7     8.4
 11   0.0     20.0       15     3.4   .070      0.0      I         R        R       R
 12   0.0      2.0       33     2.7   .120      0.0      I         R        R       R
 13   0.0    268.3    14032   874.9   .025      3.0    0.0      2.27    118.7     7.4
 14   0.0     86.3     3614   795.6   .055      6.0    0.0       .79     33.3     7.3
 15   0.0     32.4      452  1436.6   .035      3.4    0.0       .33      4.7    14.8
 16   0.0     31.1      287  1368.8   .060      5.3    0.0       .35      3.2    15.4
 17   0.0     51.0      118  1381.4   .060      3.5    0.0       .86      2.0    23.4
 18   0.0     24.0       90   575.0  0.000      0.0    0.0       .81      3.0    19.3
 19   0.0     24.5       81   287.6   .065      1.4    0.0      1.14      3.8    13.4
 20   0.0     19.9       71   104.9  0.000      0.0    0.0      2.07      7.4    10.9
 21   0.0     47.3       66    53.9  0.000      0.0    0.0     21.58     29.9    24.6
 22   0.0     23.2        6     1.6   .080      0.0      I         R        R       R
 23   0.0      3.1       20      .3   .060      0.0      I         R        R       R

CYCLE COMPOSITE     HC       1.016    GRAM/BHP HR
                    CO      22.670    GRAM/BHP HR
                    NO2     14.178    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .567      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-13-72 RUN-2    ENG. 2-3  1972 VERSION A-CATALYTIC W/AIR 16 BTDC
-------------------------------------------------------------------------------------
               DYNA.        MAN.  FUEL    A/F               DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC.  LB/HR  RATIO    ALDE.    HC      CO       CO2     NO
-------------------------------------------------------------------------------------
  1   600      0.0     0   19.0    3.3   25.8        0   1451    .050     8.04     31
  2  1200      5.0     1   20.5    5.6   25.7        0    216    .100     8.34     57
  3  1200     21.0     5   19.1    7.0   25.1        0    194    .100     8.54    100
  4  1200     46.0    11   17.6   10.2   24.5        0    303    .050     8.68    460
  5  1200     64.0    15   16.4   11.1   23.9        0    298    .020     8.93    730
  6  1200    129.0    29    9.3   15.1   21.3        0    345    .020    10.25   1625
  7  1200    193.0    44    5.5   20.2   18.3        0    377    .020    11.84   2750
  8  1200    212.0    48    3.8   21.9   18.0        0    423    .050    12.09   2800
  9  1200    232.0    53    2.3   23.6   17.8        0    473    .050    12.22   3150
 10  1200    258.0    59     .3   32.0   14.4        0   1996   2.970    12.22   1225
 11   600      0.0     0   19.5    3.3   23.3        0   8625    .100     8.34     32
 12  1200      0.0     0   23.3    2.8   44.1        0    613    .130     4.45     43
 13  2300    272.0   119     .5   62.1   14.3        0   1436   4.160    11.92   1125
 14  2300    250.0   104    3.0   47.5   16.1        0    192    .180    13.77   2200
 15  2300    223.0    98    5.0   44.1   16.6        0    145    .130    13.48   2425
 16  2300    204.0    89    6.2   41.0   16.8        0    142    .130    13.18   2250
 17  2300    136.0    60   10.1   28.0   20.3        0    287    .100    11.01   2800
 18  2300     68.0    30   16.0   18.8   22.7        0    199    .050     9.64   1450
 19  2300     49.0    21   17.5   16.9   23.8        0    141    .050     9.14    900
 20  2300     22.0    10   19.8   12.9   25.9        0    108    .050     8.48    270
 21  2300      5.0     2   21.2    9.4   27.2        0    188    .050     8.04    132
 22   600      0.0     0   19.0    3.3   27.2        0     75    .050     8.04     30
 23  2300      0.0     0   24.9    2.8   58.3        0   4950    .050     3.02      7
-------------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.       HP  ALDE.     HC       CO     NO2
-------------------------------------------------------------------------------------
  1   0.0    26.1      18     1.8  .070      0.0      I      R        R       R
  2   0.0     6.4      60     5.7  .060       .1    0.0   5.65     52.9     5.0
  3   0.0     7.1      74    12.2  .060       .3    0.0   1.49     15.5     2.5
  4   0.0    16.0      53    80.6  .050       .5    0.0   1.52      5.1     7.7
  5   0.0    16.7      23   135.8  .030       .4    0.0   1.14      1.5     9.3
  6   0.0    23.0      27   359.1  .060      1.8    0.0    .78       .9    12.2
  7   0.0    29.1      31   704.2 0.000      0.0    0.0    .66       .7    16.0
  8   0.0    34.5      82   757.7  .040      1.9    0.0    .71      1.7    15.6
  9   0.0    41.2      88   910.8 0.000      0.0    0.0    .78      1.7    17.2
 10   0.0   188.0    5650   383.0 0.000      0.0    0.0   3.19     95.8     6.5
 11   0.0   137.4      32     1.7  .070      0.0      I      R        R       R
 12   0.0    16.8      72     3.9  .120      0.0      I      R        R       R
 13   0.0   249.3   14590   648.5  .025      3.0    0.0   2.09    122.5     5.4
 14   0.0    29.6     561  1127.8  .055      6.0    0.0    .27      5.1    10.3
 15   0.0    21.3     385  1181.0  .035      3.4    0.0    .22      3.9    12.1
 16   0.0    19.8     367  1042.6  .060      5.4    0.0    .22      4.1    11.7
 17   0.0    32.7     230  1058.8  .060      3.6    0.0    .55      3.9    17.8
 18   0.0    17.5      89   423.5 0.000      0.0    0.0    .59      3.0    14.2
 19   0.0    11.7      84   248.6  .065      1.4    0.0    .55      3.9    11.6
 20   0.0     7.4      69    61.2 0.000      0.0    0.0    .76      7.2     6.3
 21   0.0     9.8      53    23.0 0.000      0.0    0.0   4.50     24.2    10.5
 22   0.0     1.4      19     1.8  .080      0.0      I      R        R       R
 23   0.0   176.3      36      .8  .060      0.0      I      R        R       R

CYCLE COMPOSITE     HC      1.497    GRAM/BHP HR
                    CO     17.373    GRAM/BHP HR
                    NO2    11.657    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .560      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-12-72 RUN 1   ENG. 2-3  1972 VERSION, A-CATALYTIC W/AIR STD
-----------------------------------------------------------------------------------------
              DYNA.        MAN.  FUEL    A/F                 DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO   ALDE.     HC      CO        CO2      NO
-----------------------------------------------------------------------------------------
  1   600      0.0     0   18.5    3.7   26.0       0     156    .050       8.60     28
  2  1200      5.0     1   19.5    7.0   25.8       0      73    .050       8.60     45
  3  1200     19.0     4   18.4    7.7   25.6       0     124    .050       8.60    105
  4  1200     42.0    10   17.5    8.3   25.0       0     157    .050       8.75    190
  5  1200     59.0    13   15.7   10.1   23.5       0     186    .050       9.37    480
  6  1200    117.0    27    8.8   16.0   21.1       0     134    .050      10.66    865
  7  1200    176.0    40    4.9   20.6   19.1       0     133    .050      11.42   1650
  8  1200    192.0    44    3.6   22.1   18.8       0     119    .050      12.22   1700
  9  1200    215.0    49    2.0   23.8   18.0       0     144    .050      12.47   2150
 10  1200    234.0    53     .3   31.5   14.6       0     869   2.780      12.71    825
 11   600      0.0     0   18.9    3.7   24.5       0     108    .050       8.93     50
 12  1200      0.0     0   23.0    3.7   35.7       0    1121    .050       5.96     15
 13  2300    263.0   115     .5   63.8   13.8       0     863   4.020      12.22    763
 14  2300    241.0   106    2.8   51.4   16.4       0      58    .100      13.77   1813
 15  2300    216.0    95    4.8   43.6   16.7       0      45    .070      13.48   1700
 16  2300    192.0    86    6.2   42.0   17.0       0      42    .070      13.33   1700
 17  2300    132.0    58    9.3   28.8   20.4       0      74    .100      11.13   1612
 18  2300     66.0    29   15.8   19.8   23.1       0      74    .050       9.78    450
 19  2300     47.0    21   17.2   17.4   24.1       0      62    .020       9.25    625
 20  2300     21.0     9   19.4   13.5   25.8       0      43    .020       8.60    215
 21  2300      5.0     2   21.0   11.3   27.4       0      40    .020       8.14     99
 22   600      0.0     0   18.5    3.7   26.2       0     182    .020       8.48     32
 23  2300      0.0     0   25.0    3.5   59.8       0    3280    .070       3.08      5
-----------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO      NO2   FAC.      HP   ALDE.       HC        CO      NO2
-----------------------------------------------------------------------------------------
  1   0.0     3.0      19      1.8  .070      0.0       I        R         R        R
  2   0.0     2.2      37      5.5  .060       .1     0.0     2.35      32.3      4.8
  3   0.0     5.0      41     14.1  .060       .3     0.0     1.16       4.4      3.3
  4   0.0     6.7      43     27.0  .050       .5     0.0      .70       4.5      2.8
  5   0.0     4.1      49     77.7  .030       .4     0.0      .67       3.7      5.8
  6   0.0     4.1      68    194.6  .060      1.6     0.0      .34       2.6      7.3
  7   0.0    10.4      79    427.8 0.000      0.0     0.0      .26       2.0     10.6
  8   0.0     4.2      82    460.7  .040      1.8     0.0      .22       1.9     10.5
  9   0.0    12.4      87    614.8 0.000      0.0     0.0      .25       1.8     12.5
 10   0.0    29.8    5154    251.4 0.000      0.0     0.0     1.49      96.4      4.7
 11   0.0     6.0      19      3.1  .070      0.0       I        R         R        R
 12   0.0    30.5      27      1.3  .120      0.0       I        R         R        R
 13   0.0   153.0   14401    448.9  .025      2.9     0.0     1.33     125.0      3.9
 14   0.0     4.7     334   1011.3  .055      5.8     0.0      .09       3.2      4.6
 15   0.0     6.5     206    823.5  .035      3.3     0.0      .07       2.2      8.7
 16   0.0     5.3     201    802.4  .060      5.2     0.0      .07       2.3      9.2
 17   0.0     8.6     235    623.2  .060      3.5     0.0      .15       4.1     10.8
 18   0.0     6.8      92    287.4 0.000      0.0     0.0      .23       3.2      9.9
 19   0.0     5.3      34    176.8  .065      1.3     0.0      .26       1.7      8.6
 20   0.0     3.1      29     50.7 0.000      0.0     0.0      .33       3.1      5.5
 21   0.0     2.5      25     20.7 0.000      0.0     0.0     1.15      11.6      9.4
 22   0.0     4.5       8      2.1  .080      0.0       I        R         R        R
 23   0.0   161.0      65       .8  .060      0.0       I        R         R        R

CYCLE COMPOSITE     HC        .747    GRAM/BHP HR
                    CO      16.593    GRAM/BHP HR
                    NO2      8.602    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .612      LB/BHP HR
```

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-12-72 RUN-2   ENG. 2-3  1972 VERSION  A-CATALYTIC W/AIR STD
-----------------------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR   RATIO   ALDE.     HC      CO       CO2     NO
-----------------------------------------------------------------------------------------------
   1   600     0.0     0  18.5   4.0    26.4       0    345    .020      8.34     26
   2  1200     5.0     1  19.6   7.1    24.9       0    127    .070      8.84     47
   3  1200    19.0     4  18.8   7.4    25.7       0    108    .020      8.68     84
   4  1200    42.0    10  16.8   8.3    24.5       0    175    .020      9.14    265
   5  1200    59.0    13  15.7  10.0    23.3       0    198    .020      9.78    575
   6  1200   117.0    27   9.8  15.1    21.3       0    163    .020     11.01    820
   7  1200   176.0    40   4.8  21.4    18.9       0    173    .020     12.34   1800
   8  1200   192.0    44   3.8  22.0    18.4       0    143    .020     12.34   1712
   9  1200   215.0    49   2.4  23.1    18.2       0    166    .020     12.34   2150
  10  1200   234.0    53    .3  31.5    19.8       0   1007   2.690     12.94    987
  11   600     0.0     0  19.0   3.9    25.1       0    121    .020      9.03     35
  12  1200     0.0     0  23.0   3.6    38.6       0   2231    .020      5.39      9
  13  2300   263.0   115    .5  63.0    14.0       0    789   3.790     12.22    825
  14  2300   241.0   106   2.7  51.3    15.4       0    148    .810     13.77    900
  15  2300   216.0    95   4.7  45.4    16.6       0     54    .050     13.63   1650
  16  2300   197.0    86   6.0  41.2    17.2       0     40    .050     13.18   1825
  17  2300   132.0    58  10.0  28.8    21.0       0     72    .050     10.78   1650
  18  2300    66.0    29  15.6  18.6    23.4       0     70    .050      9.64    950
  19  2300    47.0    21  17.5  16.1    24.6       0     54    .050      9.03    530
  20  2300    21.0     9  19.2  13.9    25.7       0     43    .050      8.68    245
  21  2300     5.0     2  21.0  11.2    27.5       0     39    .050      8.14    115
  22   600     0.0     0  16.5   3.9    28.1       0    212    .050      7.85     30
  23  2300     0.0     0  24.8   3.5    61.5       0   2733    .100      3.03      8
-----------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO     NO2  FAC.       HP  ALDE.      HC      CO     NO2
-----------------------------------------------------------------------------------------------
   1   0.0    7.4        9     1.9  .070      0.0      I       R       R       R
   2   0.0    4.6       51     5.7  .060       .1    0.0    4.04    44.9     5.0
   3   0.0    4.2       16    10.7  .060       .3    0.0     .96     3.6     2.5
   4   0.0    7.2       17    36.0  .050       .5    0.0     .75     1.7     3.8
   5   0.0    9.1       19    88.3  .030       .4    0.0     .68     1.4     6.5
   6   0.0   10.1       25   168.6  .060      1.6    0.0     .38      .9     6.3
   7   0.0   13.5       32   467.6 0.000      0.0    0.0     .34      .8    11.6
   8   0.0   11.6       33   458.4  .040      1.8    0.0     .26      .7    10.4
   9   0.0   14.0       34   604.6 0.000      0.0    0.0     .29      .7    12.3
  10   0.0   91.5     4936   297.6 0.000      0.0    0.0    1.71    92.3     5.6
  11   0.0    2.4        8     2.3  .070      0.0      I       R       R       R
  12   0.0   64.7       12      .9  .120      0.0      I       R       R       R
  13   0.0  140.2    13594   486.3  .025      2.9    0.0    1.22   118.0     4.2
  14   0.0   23.5     2609   476.4  .055      5.8    0.0     .22    24.7     4.5
  15   0.0    8.2      152   824.9  .035      3.3    0.0     .09     1.6     8.7
  16   0.0    5.7      143   856.0  .060      5.2    0.0     .07     1.7     9.9
  17   0.0    8.7      122   661.3  .060      3.5    0.0     .15     2.1    11.4
  18   0.0    6.1       88   274.1 0.000      0.0    0.0     .21     3.0     9.5
  19   0.0    4.3       81   141.1  .065      1.3    0.0     .21     3.9     6.9
  20   0.0    3.1       73    58.8 0.000      0.0    0.0     .34     7.9     6.4
  21   0.0    2.4       63    23.7 0.000      0.0    0.0    1.10    28.7    10.8
  22   0.0    4.8       23     2.2  .080      0.0      I       R       R       R
  23   0.0  128.6       95     1.2  .060      0.0      I       R       R       R

CYCLE COMPOSITE    HC       .941   GRAM/BHP HR
                   CO     19.890   GRAM/BHP HR
                   NO2     7.607   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .607     LB/BHP HR
```

```
                              PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-13-72 RUN 3   ENG. 2-3  1972 VERSION  A-CATALYTIC W/AIR 4 ATDC
-------------------------------------------------------------------------------------------
             DYNA.          MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED   LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC        CO        CO2      NO
-------------------------------------------------------------------------------------------
   1   600     0.0     0   16.5   4.6    24.2        0    260      .050       8.93      44
   2  1200     4.0     1   18.7   7.6    25.4        0    101      .050       8.60      56
   3  1200    16.0     4   18.2   7.8    25.4        0    108      .050       8.60      68
   4  1200    37.0     8   16.4   9.8    24.2        0    130      .050       8.93     167
   5  1200    51.0    12   15.4  10.0    23.8        0    133      .050       9.03     200
   6  1200   102.0    23    7.8  17.6    20.1        0     80      .050      11.24     615
   7  1200   153.0    35    4.1  22.3    18.5        0     92      .050      11.84    1125
   8  1200   167.0    38    3.0  22.9    18.3        0     74      .050      11.84    1300
   9  1200   188.0    43    1.8  24.4    17.8        0     81      .050      12.34    1525
  10  1200   204.0    47     .3  31.5    14.7        0    416     2.360      12.82     660
  11   600     0.0     0   17.0   4.2    23.9        0    116      .020       8.84      48
  12  1200     0.0     0   22.0   4.4    33.0        0     23      .050       6.30      10
  13  2300   236.0   103     .5  64.3    13.8        0    641     3.700      11.92     600
  14  2300   217.0    95    2.4  53.6    14.9        0    182     1.230      13.48     580
  15  2300   194.0    85    4.2  46.0    16.3        0    106      .100      13.48    1100
  16  2300   177.0    78    5.5  42.7    16.7        0    110      .070      13.33    1063
  17  2300   118.0    52    9.3  30.8    20.3        0    107      .070      11.01     950
  18  2300    59.0    26   15.5  18.5    22.9        0     99      .070       9.64     520
  19  2300    42.0    18   16.9  18.0    23.8        0     77      .070       9.14     360
  20  2300    19.0     8   18.9  14.0    25.0        0     50      .070       8.75     152
  21  2300     5.0     2   20.2  12.2    26.1        0     37      .070       8.34      90
  22   600     0.0     0   16.5   4.5    24.7        0    188      .050       8.75      43
  23  2300     0.0     0   24.1   4.6    51.3        0   4647      .070       3.45       5
-------------------------------------------------------------------------------------------
            CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.       HP  ALDE.       HC        CO      NO2
-------------------------------------------------------------------------------------------
   1   0.0     6.0       23      3.4   .070      0.0     I         R         R        R
   2   0.0     4.0       40      7.4   .060       .1    0.0      4.39      43.8      8.1
   3   0.0     4.4       42      9.4   .060       .2    0.0      1.21      11.4      2.6
   4   0.0     6.4       50     27.5   .050       .4    0.0       .76       5.9      3.2
   5   0.0     6.6       50     33.0   .030       .3    0.0       .57       4.3      2.8
   6   0.0     5.7       71    144.3   .060      1.4    0.0       .24       3.1      6.2
   7   0.0     7.8       86    317.2  0.000      0.0    0.0       .22       2.5      9.1
   8   0.0     6.5       88    376.2   .040      1.5    0.0       .17       2.3      9.9
   9   0.0     7.2       90    452.7  0.000      0.0    0.0       .17       2.1     10.5
  10   0.0    39.0     4472    205.6  0.000      0.0    0.0       .84      95.9      4.4
  11   0.0     2.5        9      3.4   .070      0.0     I         R         R        R
  12   0.0      .7       32      1.1   .120      0.0     I         R         R        R
  13   0.0   119.2    13905    370.6   .025      2.6    0.0      1.15     134.5      3.6
  14   0.0    30.0     4102    317.9   .055      5.2    0.0       .32      43.2      3.3
  15   0.0    16.3      310    561.2   .035      3.0    0.0       .19       3.7      6.6
  16   0.0    15.8      204    509.0   .060      4.7    0.0       .20       2.6      6.6
  17   0.0    13.5      178    397.6   .060      3.1    0.0       .26       3.4      7.7
  18   0.0     8.6      122    149.0  0.000      0.0    0.0       .33       4.7      5.8
  19   0.0     6.9      126    106.1   .065      1.2    0.0       .37       6.8      5.8
  20   0.0     3.6      102     36.3  0.000      0.0    0.0       .43      12.2      4.4
  21   0.0     2.4       93     19.6  0.000      0.0    0.0      1.11      42.4      9.0
  22   0.0     4.4       24      3.3   .080      0.0     I         R         R        R
  23   0.0   240.7       73       .9   .060      0.0     I         R         R        R

CYCLE COMPOSITE    HC      1.034   GRAM/BHP HR
                   CO     27.178   GRAM/BHP HR
                   NO2     5.724   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .726     LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-14-72 RUN-3    ENG.2-3 72-VER. A-CATA. W/AIR STD. J.-0.075 R.0.038
------------------------------------------------------------------------------------
               DYNA.          MAN.  FUEL    A/F                    DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC.  LB/HR   RATIO    ALDE.      HC       CO       CO2      NO
------------------------------------------------------------------------------------
  1    600      0.0     0   18.0    3.9    24.9        0      38     .050      8.75      35
  2   1200      5.0     1   19.6    7.1    24.2        0      71     .050      8.93      65
  3   1200     18.0     4   18.9    7.9    23.5        0      42     .050      9.37      96
  4   1200     41.0     9   17.8    9.0    22.3        0      35     .050      9.93     320
  5   1200     58.0    13   16.7    9.9    21.2        0      60     .050     10.55     550
  6   1200    115.0    26   11.8   14.3    19.3        0      59     .280     11.24    1337
  7   1200    173.0    40    6.0   21.9    16.7        0      85     .100     13.33     755
  8   1200    189.0    43    4.4   23.4    16.6        0      41     .100     13.48     900
  9   1200    212.0    48    2.8   25.6    16.3        0      43     .150     13.77     963
 10   1200    230.0    53     .3   32.3    14.1        0      70    3.700     11.92     615
 11    600      0.0     0   18.5    3.9    24.2        0      45     .020      9.03      41
 12   1200      0.0     0   22.5    3.7    35.5        0      35     .020      6.05       8
 13   2300    262.0   115     .5   64.9    13.7        0      80    4.350     12.22     690
 14   2300    239.0   105    2.1   58.0    14.0        0      41    3.420     12.71     360
 15   2300    213.0    93    4.5   47.1    14.8        0      77    1.630     13.77     675
 16   2300    195.0    85    5.8   47.0    15.1        0      79     .970     14.31     690
 17   2300    130.0    57   11.2   30.3    18.2        0      82     .050     12.47    1837
 18   2300     65.0    28   16.4   20.3    20.6        0      49     .050     11.13    1100
 19   2300     47.0    21   17.5   18.3    21.1        0      87     .050     10.78     790
 20   2300     21.0     9   19.8   13.9    23.2        0      31     .050      9.64     280
 21   2300      5.0     2   21.0   12.7    23.7        0      76     .100      9.25     175
 22    600      0.0     0   18.0    3.9    24.9        0      44     .050      8.84      41
 23   2300      0.0     0   24.4    3.9    54.5        0      16     .100      3.68       4
------------------------------------------------------------------------------------
          CALCULATED GRAM/HR            WT.      WT.   BRAKE  SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.      HP   ALDE.      HC       CO     NO2
------------------------------------------------------------------------------------
  1    0.0      .8       21      2.4   .070     0.0       I       R        R       R
  2    0.0     2.5       36      7.8   .060      .1     0.0    2.22     31.6     6.8
  3    0.0     1.6       38     12.1   .060      .2     0.0     .39      9.3     2.9
  4    0.0     1.4       41     43.3   .050      .5     0.0     .15      4.4     4.6
  5    0.0     2.6       43     77.3   .030      .4     0.0     .19      3.2     5.8
  6    0.0     3.3      318    249.7   .060     1.6     0.0     .13     12.1     9.5
  7    0.0     6.3      149    184.9  0.000     0.0     0.0     .16      3.8     4.7
  8    0.0     3.2      158    233.9   .040     1.7     0.0     .07      3.7     5.4
  9    0.0     3.6      252    266.1  0.000     0.0     0.0     .07      5.2     5.5
 10    0.0     6.6     7005    191.4  0.000     0.0     0.0     .13    133.3     3.6
 11    0.0      .9        8      2.7   .070     0.0       I       R        R       R
 12    0.0     1.0       11       .8   .120     0.0       I       R        R       R
 13    0.0    14.1    15606    406.9   .025     2.9     0.0     .12    136.0     3.5
 14    0.0     6.7    11265    194.9   .055     5.8     0.0     .06    107.6     1.9
 15    0.0    10.7     4565    310.7   .035     3.3     0.0     .11     48.9     3.3
 16    0.0    11.0     2731    319.3   .060     5.1     0.0     .13     32.0     3.7
 17    0.0     9.0      111    669.5   .060     3.4     0.0     .16      1.9    11.8
 18    0.0     4.0       83    301.2  0.000     0.0     0.0     .14      2.9    10.6
 19    0.0     6.7       77    201.1   .065     1.3     0.0     .32      3.8     9.8
 20    0.0     2.0       66     60.5  0.000     0.0     0.0     .22      7.1     6.6
 21    0.0     4.7      124     35.7  0.000     0.0     0.0    2.13     56.7    16.3
 22    0.0      .9       20      2.7   .080     0.0       I       R        R       R
 23    0.0      .8       95       .6   .060     0.0       I       R        R       R

CYCLE COMPOSITE      HC       .145   GRAM/BHP HR
                     CO     52.906   GRAM/BHP HR
                     NO2     5.138   GRAM/BHP HR
                     ALDE    0.000   GRAM/BHP HR
                     BSFC     .658     LB/BHP HR
```

```
                              PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-14-72 RUN-2      ENG. 2-3  1972 VERSION  A-CATALYTIC W/O AIR STD
-----------------------------------------------------------------------------------
                 DYNA.         MAN.  FUEL    A/F            DRY CONCENTRATION
MODE SPEED       LOAD   HP   VAC. LB/HR   RATIO   ALDE.    HC      CO      CO2    NO
-----------------------------------------------------------------------------------
   1   600       0.0     0   18.0    3.6    17.4      0    683   .050   12.47    40
   2  1200       5.0     1   19.2    7.3    17.2      0    123   .050   12.82    71
   3  1200      18.0     4   18.7    7.4    17.2      0     90   .050   12.82    85
   4  1200      41.0     9   17.0    9.6    17.6      0    192   .050   12.34   430
   5  1200      58.0    13   15.1   10.2    17.5      0    192   .050   12.22   570
   6  1200     115.0    25    8.4   16.6    16.6      0    191   .050   13.06  1188
   7  1200     173.0    40    4.7   20.7    15.3      0   4573   .050   13.91  1875
   8  1200     189.0    43    3.6   21.3    15.8      0    467   .070   13.48  1975
   9  1200     212.0    48    2.2   23.6    15.5      0    712   .100   13.91  2200
  10  1200     230.0    53     .3   31.7    13.0      0   2882  5.290   11.24  1000
  11   600       0.0     0   18.5    3.6    15.3      0   2626  1.770   12.22    48
  12  1200       0.0     0   22.5    4.5    18.8      0     35   .100   11.84    22
  13  2300     260.0   114     .5   62.1    12.9      0   2278  5.450   11.13  1112
  14  2400     239.0   105    3.0   47.5    14.7      0    107  1.590   13.48  2063
  15  2300     213.0    93    4.8   44.6    14.8      0    899  1.300   13.63  1987
  16  2300     195.0    85    6.0   41.9    14.7      0   1085  1.480   13.91  1987
  17  2300     130.0    57    9.8   29.5    17.0      0     94   .020   13.33  1800
  18  2300      65.0    28   15.4   17.7    17.4      0     75   .020   12.94  1162
  19  2300      47.0    21   16.8   17.0    17.4      0     55   .020   13.06   720
  20  2300      21.0     4   19.1   13.3    17.6      0     26   .050   13.06   285
  21  2400       5.0     2   20.5   11.4    17.7      0     16   .050   12.94   188
  22   600       0.0     0   19.0    3.6    18.2      0    262   .020   12.47    45
  23  2300       0.0     0   24.5    3.6    26.6      0     61   .020    8.34    11
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2   FAC.      HP  ALDE.      HC      CO     NO2
-----------------------------------------------------------------------------------
   1   0.0    4.0      13     1.7   .070     0.0     I       R       R       R
   2   0.0    3.2      26     6.1   .160      .1   0.0    2.77    22.8     5.3
   3   0.0    2.3      26     7.3   .060      .2   0.0     .57     6.4     1.8
   4   0.0    6.8      35    50.1   .050      .5   0.0     .72     3.8     5.4
   5   0.0    7.2      38    71.4   .030      .4   0.0     .55     2.9     5.4
   6   0.0   10.9      58   225.6   .060     1.6   0.0     .42     2.2     8.6
   7   0.0  247.2      56   404.6  0.000     0.0   0.0    7.52     1.7    10.2
   8   0.0   33.2     100   465.5   .040     1.7   0.0     .77     2.3    10.8
   9   0.0   54.1     153   554.8  0.000     0.0   0.0    1.12     3.2    11.5
  10   0.0  246.6    9142   284.0  0.000     0.0   0.0    4.69   174.0     5.4
  11   0.0   30.3     412     1.8   .070     0.0     I       R       R       R
  12   0.0     .6      34     1.2   .120     0.0     I       R       R       R
  13   0.0  381.6   18444   618.8   .025     2.8   0.0    3.35   162.0     5.4
  14   0.0   15.3    4541   978.7   .055     5.8   0.0     .15    43.9     9.4
  15   0.0  121.1    3537   888.8   .035     3.3   0.0    1.30    37.9     9.5
  16   0.0  133.2    3670   909.9   .060     5.1   0.0    1.56    43.0     9.5
  17   0.0    9.4      40   598.2   .060     3.4   0.0     .17      .7    10.5
  18   0.0    4.6      25   239.1  0.000     0.0   0.0     .16      .9     8.4
  19   0.0    3.2      24   141.1   .065     1.3   0.0     .16     1.2     6.9
  20   0.0    1.2      46    43.5  0.000     0.0   0.0     .13     5.0     4.7
  21   0.0     .6      40    24.9  0.000     0.0   0.0     .29    18.4    11.4
  22   0.0    3.5       5     2.0   .080     0.0     I       R       R       R
  23   0.0    1.2       8      .7   .060     0.0     I       R       R       R

CYCLE COMPOSITE   HC      1.121    GRAM/BHP HR
                  CO     42.312    GRAM/BHP HR
                  NO2     8.855    GRAM/BHP HR
                  ALDE    0.000    GRAM/BHP HR
                  BSFC     .617      LB/BHP HR
```

ENGINE 2-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

GRAPHED RESULTS

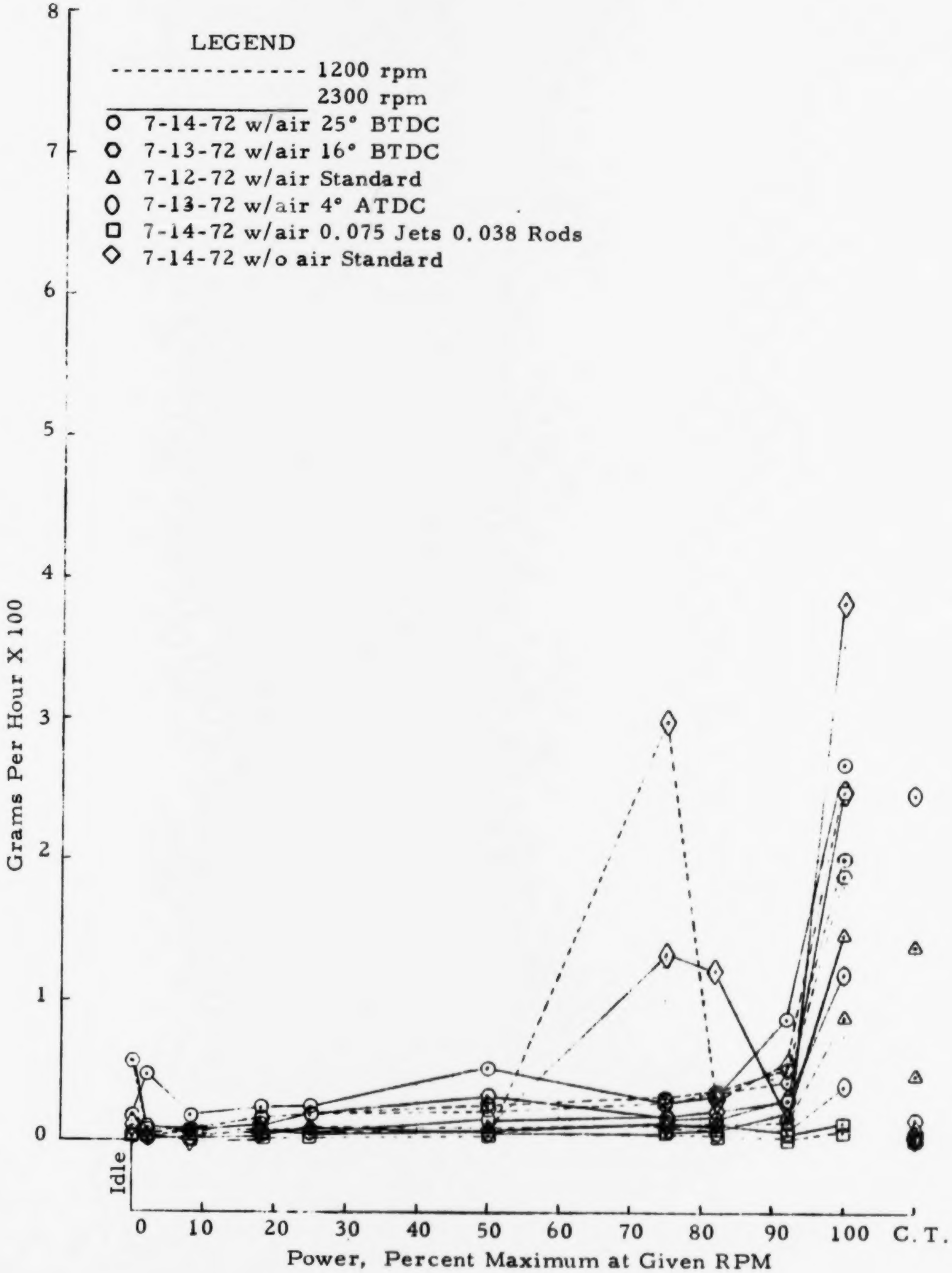


FIGURE M-1. EFFECT OF POWER ON HC EMISSION RATE - AFTER OXIDATION CATALYST ENGINE 2-3, 23 MODE TEST

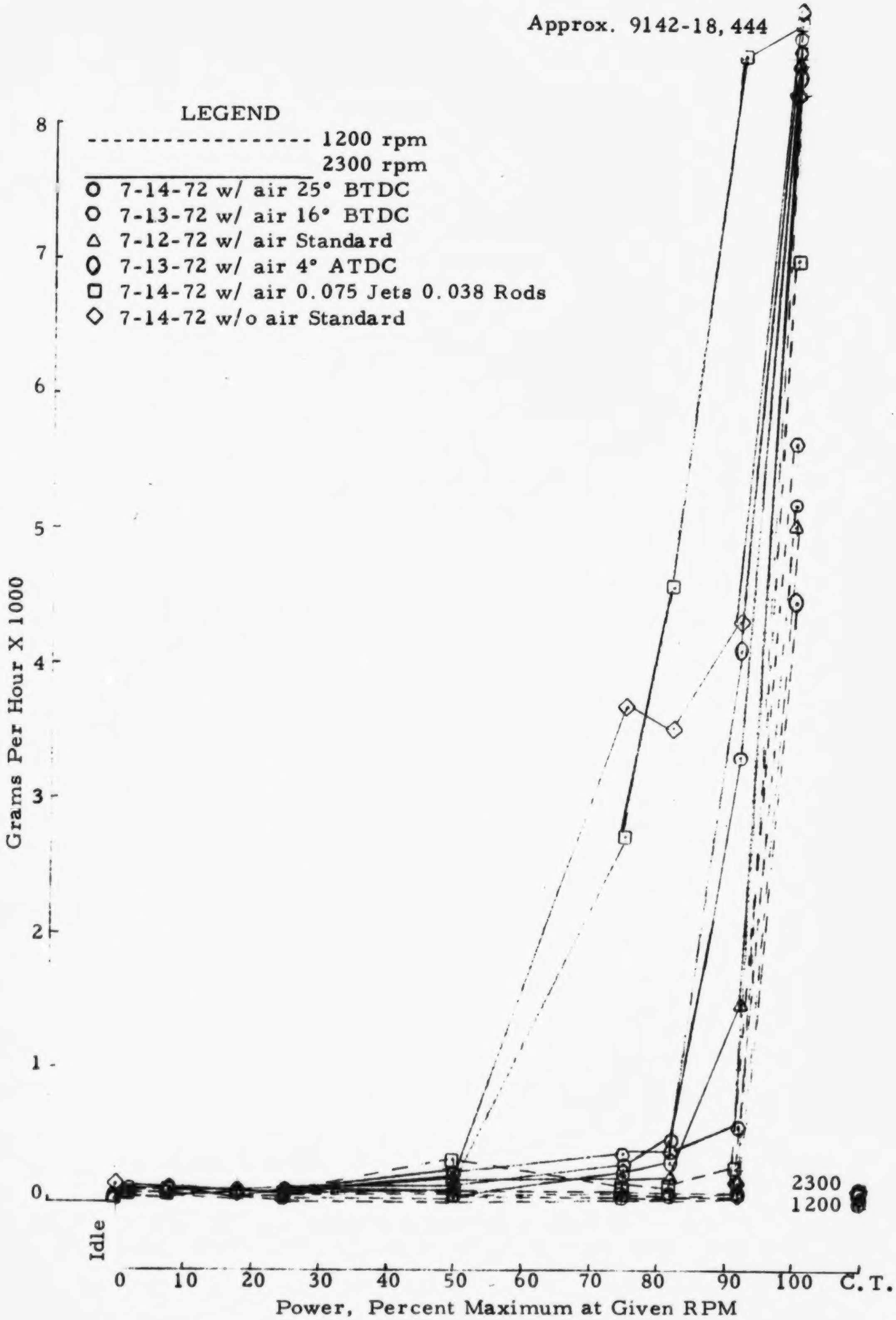


FIGURE M-2. EFFECT OF POWER ON CO EMISSION RATE - AFTER OXIDATION CATALYST ENGINE 2-3, 23 MODE TEST

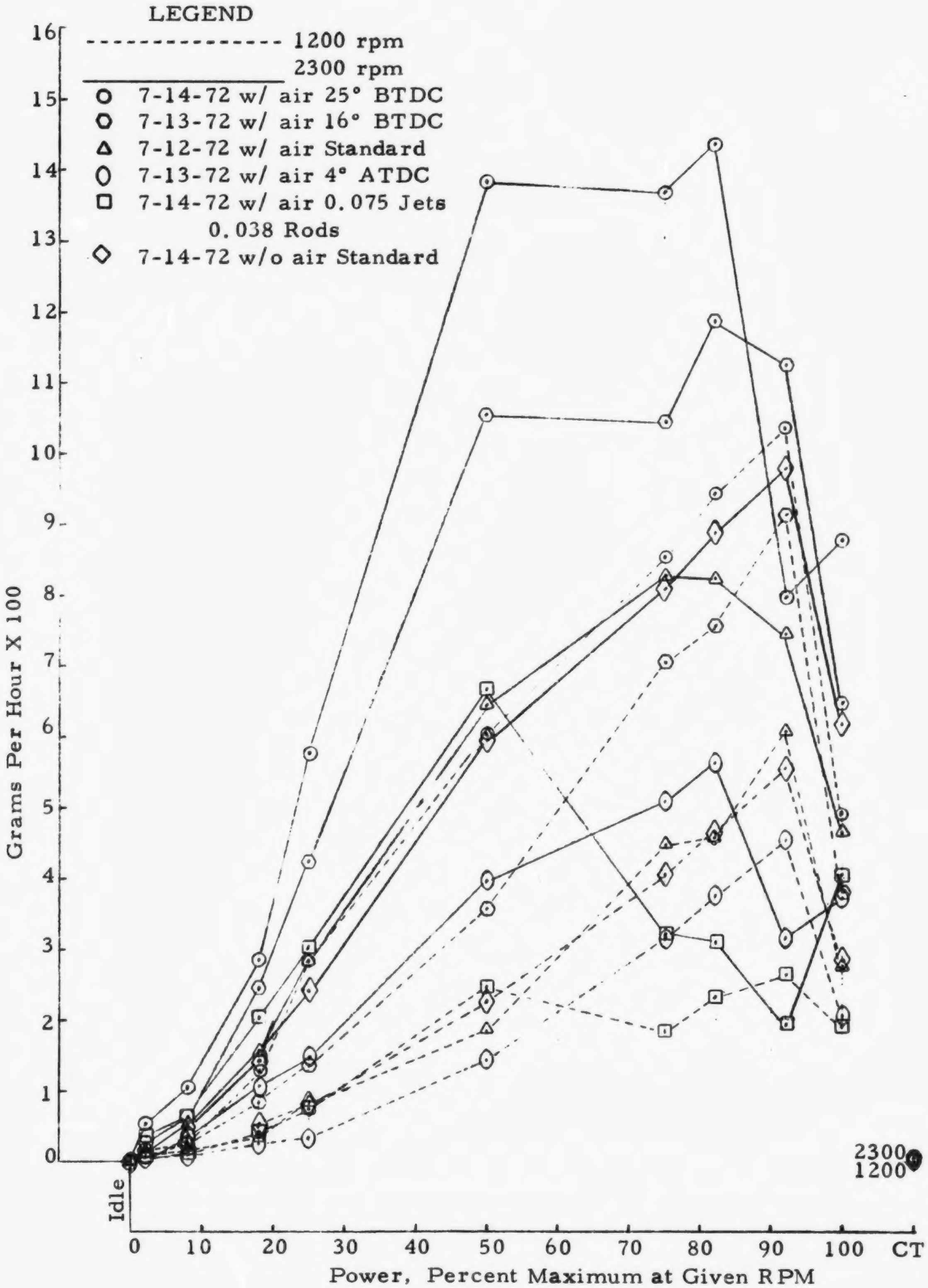


FIGURE M-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE - AFTER OXIDATION CATALYST ENGINE 2-3, 23 MODE TEST

300

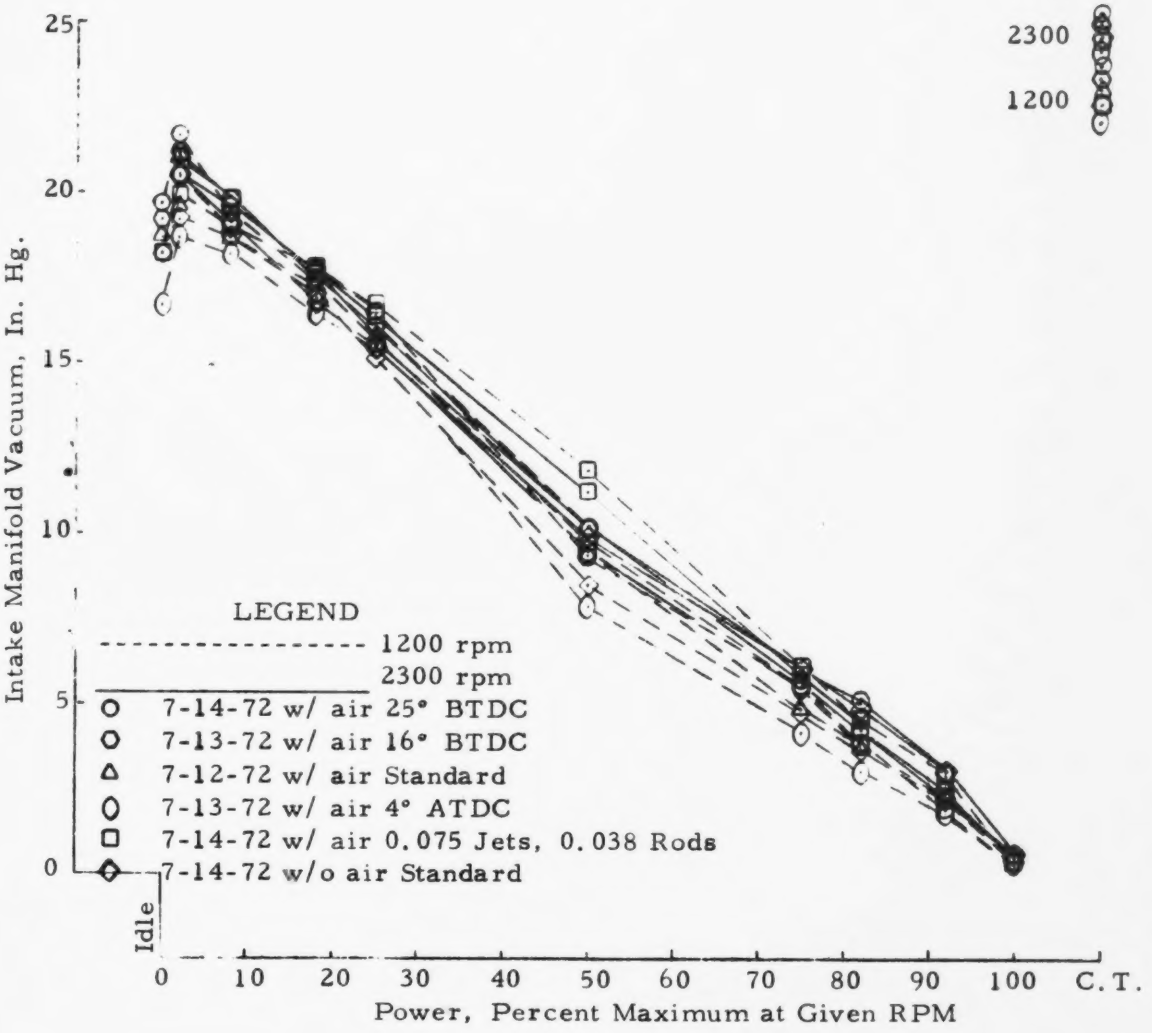


FIGURE M-4. MANIFOLD VACUUM AS A FUNCTION OF POWER - OXIDATION CATALYST
ENGINE 2-3, 23 MODE TEST

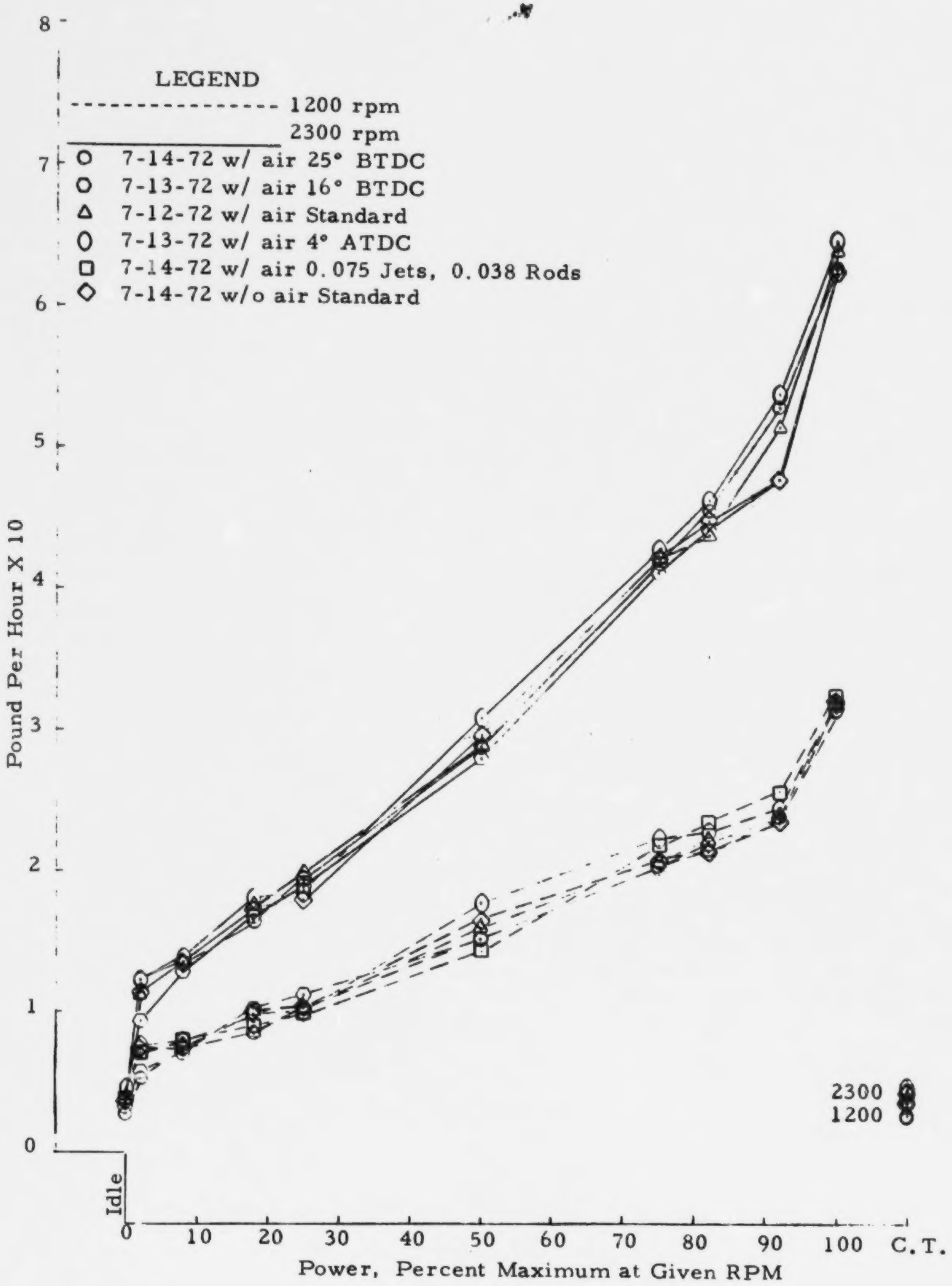


FIGURE M-5. FUEL CONSUMPTION AS A FUNCTION OF POWER - OXIDATION CATALYST
ENGINE 2-3, 23 MODE TEST

APPENDIX N

ENGINE 2-3

EFFECT OF ENGINE DERATING ON EMISSIONS

(23 MODE MASS RESULTS)

```
                      PROJECT 11-2877-0   CONTROL TECHNOLOGY
  7-26-72 RUN1        ENG.2-3  1972-VERSION- STD-TIM-STD-4BBL-W/REAR PLUG
------------------------------------------------------------------------------------------
               DYNA.           MAN.  FUEL      A/F               DRY CONCENTRATION
MODE SPEED     LOAD      HP    VAC.  LB/HR    RATIO    ALDE.      HC      CO       CO2     NO
------------------------------------------------------------------------------------------
  1    600      0.0       0    18.3    3.1    18.8        0     4145   1.160    11.84     35
  2   1200      5.0       1    20.3    6.7    16.3        0      671    .390    13.48     70
  3   1200     14.0       4    19.1    7.3    16.6        0      968    .150    13.48    169
  4   1200     42.0      10    18.2    7.9    16.6        0     1560    .130    13.06    395
  5   1200     54.0      13    17.2    9.2    16.5        0     1730    .130    13.18    645
  6   1200    117.0      27    11.2   14.0    16.8        0     1502    .130    12.94   1438
  7   1200    176.0      40     5.7   20.9    15.7        0     1630    .180    14.05   2050
  8   1200    192.0      44     3.9   21.7    16.0        0     1298    .180    13.77   2150
  9   1200    215.0      49     2.0   23.7    15.8        0     1354    .250    13.63   2250
 10   1200    234.0      53      .5   26.1    15.4        0     1667    .850    13.63   2075
 11    600      0.0       0    18.7    3.4    15.6        0     4515   1.590    12.34     46
 12   1200      0.0       0    23.3    3.6    18.2        0    48753    .420     6.05     12
 13   2300    240.0     105     2.3   51.7    14.6        0     2080   1.630    13.48   2125
 14   2300    221.0      97     3.6   47.6    14.7        0     1478   1.660    13.18   1787
 15   2300    197.0      86     5.8   42.3    14.9        0     1138   1.270    13.63   1612
 16   2300    180.0      79     6.9   38.0    15.1        0     1261    .930    13.77   2000
 17   2300    120.0      53    11.4   28.2    16.4        0      377    .180    13.33   2000
 18   2300     60.0      26    16.9   18.3    16.6        0      374    .180    13.18   1125
 19   2300     43.0      19    18.2   16.5    16.7        0      343    .180    13.18    765
 20   2300     19.0       8    20.1   12.5    16.8        0      205    .150    13.18    300
 21   2300      5.0       2    21.3   10.6    16.8        0      115    .150    13.18    154
 22    600      0.0       0    18.3    3.3    16.4        0     3595   1.520    11.84     42
 23   2300      0.0       0    25.2    3.5    22.9        0    46623    .280     3.62      7
------------------------------------------------------------------------------------------
           CALCULATED GRAM/HR            WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2     FAC.       HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1    0.0     43.4     246      1.2    .070      0.0      I        R        R        R
  2    0.0     14.6     172      5.1    .060       .1    0.0    12.81    150.4      4.5
  3    0.0     23.4      73     13.5    .060       .3    0.0     5.38     16.8      3.1
  4    0.0     41.9      71     35.2    .050       .5    0.0     4.36      7.3      3.7
  5    0.0     53.5      81     66.3    .030       .4    0.0     3.97      6.0      4.9
  6    0.0     72.1     126    229.2    .060      1.6    0.0     2.70      4.7      8.6
  7    0.0    107.3     239    448.3   0.000      0.0    0.0     2.67      6.0     11.1
  8    0.0     90.8     254    499.0    .040      1.8    0.0     2.07      5.8     11.4
  9    0.0    103.9     387    573.0   0.000      0.0    0.0     2.11      7.9     11.7
 10    0.0    134.7    1388    556.8   0.000      0.0    0.0     2.52     26.0     10.4
 11    0.0     48.4     344      1.7    .070      0.0      I        R        R        R
 12    0.0    701.7     122       .6    .120      0.0      I        R        R        R
 13    0.0    318.4    5041   1080.1    .025      2.6    0.0     3.03     48.0     10.3
 14    0.0    213.0    4831    354.9    .055      5.3    0.0     2.20     49.9      8.8
 15    0.0    145.4    3279    684.2    .035      3.0    0.0     1.69     38.0      7.9
 16    0.0    146.6    2184    772.0    .060      4.7    0.0     1.86     27.7      9.8
 17    0.0     35.6     343    626.9    .060      3.2    0.0      .68      6.5     11.9
 18    0.0     23.1     225    231.4   0.000      0.0    0.0      .88      8.6      8.8
 19    0.0     19.1     203    141.9    .065      1.2    0.0     1.02     10.8      7.5
 20    0.0      8.7     129     42.3   0.000      0.0    0.0     1.05     15.5      5.1
 21    0.0      4.1     109     18.4   0.000      0.0    0.0     1.90     49.9      8.4
 22    0.0     39.2     335      1.5    .080      0.0      I        R        R        R
 23    0.0    864.5     105       .4    .060      0.0      I        R        R        R

CYCLE COMPOSITE      HC       7.973    GRAM/BHP HR
                     CO      32.405    GRAM/BHP HR
                     NO2      9.336    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                   * BSFC      .609      LB/BHP HR
```

APPENDIX O

ENGINE 2-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

Factory Exhaust Manifold Air Injection (Light Duty)
Factory Exhaust Gas Recirculation (Light Duty)
Standard 1972 Carburetor-Distributor
Oxidation Catalyst (Platinum Type)
Basic Spark Timing as noted

ENGINE 2-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

TABULAR 23 MODE DATA
BEFORE AND AFTER CATALYST

```
                              PROJECT 11-2877-01  CONTROL TECHNOLOGY
   7-28-72 RUN-1    ENG.2-3    1972 VERSION-  B-CATA W/AIR W/EGR 4 ATDC
-----------------------------------------------------------------------------------------
                  DYNA.             MAN.  FUEL     A/F                DRY CONCENTRATION
MODE SPEED        LOAD     HP    VAC.  LB/HR    RATIO      ALDE.      HC        CO        CO2      NO
-----------------------------------------------------------------------------------------
  1    600         0.0      0    16.5    4.0     21.5         0     1096      .280     10.09      31
  2   1200         4.0      1    10.0   11.2     21.7         0    10600      .390      8.43      17
  3   1200        15.0      3     8.7   12.6     20.6         0     2575      .280     10.09      27
  4   1200        33.0      8     6.9   14.8     19.4         0      482      .100     11.48      68
  5   1200        46.0     11     6.1   15.1     19.4         0      200      .100     11.72     100
  6   1200        92.0     21     4.4   18.7     19.0         0      200      .070     12.09     310
  7   1200       138.0     32     2.9   21.2     18.2         0      189      .100     12.22     325
  8   1200       151.0     35     2.3   22.3     18.4         0      269      .050     11.92    1000
  9   1200       169.0     39     1.4   23.4     17.9         0      293      .150     12.47    1212
 10   1200       184.0     42      .3   29.2     14.7         0      645     2.780     12.59     765
 11    600         0.0      0    17.0    5.0     21.3         0      214      .470     10.09      57
 12   1200         0.0      0    21.1    5.8     23.5         0     7967      .440      7.85      24
 13   2300       222.0     97      .6   63.0     13.4         0     1719     4.300     11.48     500
 14   2300       204.0     89     2.6   50.8     15.0         0      210      .350     13.48     925
 15   2300       182.0     80     3.6   41.8     16.8         0      123      .180     12.94     713
 16   2300       166.0     73     4.2   42.8     17.3         0      106      .150     12.59     605
 17   2300       111.0     49     6.6   34.6     18.5         0       58      .070     12.34     375
 18   2300        55.0     24    10.0   25.2     20.6         0      121      .050     10.78     142
 19   2300        40.0     18    12.4   20.9     22.9         0      350      .100      4.93     117
 20   2300        18.0      8    15.3   16.6     24.3         0      835      .150      9.03      51
 21   2300         4.0      2    17.0   15.5     22.4         0      366      .100      9.93      74
 22    600         0.0      0    16.5    4.0     23.3         0     1130      .210      4.14      34
 23   2300         0.0      0    24.4    3.6     31.3         0    51567      .050       .09       4
-----------------------------------------------------------------------------------------
             CALCULATED GRAM/HR               WT.       WT.    BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.        HC        CO       NO2     FAC.        HP    ALDE.       HC        CO      NO2
-----------------------------------------------------------------------------------------
  1    0.0      18.8        97       1.8     .070       0.0       I         R         R        R
  2    0.0     543.1       404       2.8     .060        .1     0.0    594.23     441.7      3.1
  3    0.0     138.5       304       4.8     .060        .2     0.0     40.41      88.8      1.4
  4    0.0      27.7       116      13.0     .050        .4     0.0      3.68      15.4      1.7
  5    0.0      11.6       117      19.2     .030        .3     0.0      1.10      11.1      1.8
  6    0.0      14.0        90      71.8     .060       1.3     0.0       .66       4.7      3.4
  7    0.0      14.8       158      84.3    0.000       0.0     0.0       .47       5.0      2.7
  8    0.0      22.7        85     280.2     .040       1.4     0.0       .66       2.5      8.1
  9    0.0      24.6       254     337.8    0.000       0.0     0.0       .64       6.6      8.7
 10    0.0      55.3      4812     217.7    0.000       0.0     0.0      1.32     114.5      5.2
 11    0.0       4.6       205       4.1     .070       0.0       I         R         R        R
 12    0.0     229.1       256       2.3     .120       0.0       I         R         R        R
 13    0.0     307.9     15560     297.4     .025       2.4     0.0      3.17     160.1      3.1
 14    0.0      34.9      1175     510.5     .055       4.9     0.0       .39      13.2      5.7
 15    0.0      17.8       524     341.2     .035       2.8     0.0       .22       6.6      4.3
 16    0.0      16.2       462     306.1     .060       4.4     0.0       .22       6.4      4.2
 17    0.0       7.3       179     157.2     .060       2.9     0.0       .15       3.7      3.2
 18    0.0      12.8       106      49.9    0.000       0.0     0.0       .53       4.4      2.1
 19    0.0      32.9       190      36.7     .065       1.1     0.0      1.88      10.9      2.1
 20    0.0      67.7       246      13.7    0.000       0.0     0.0      8.59      31.2      1.7
 21    0.0      25.5       141      17.1    0.000       0.0     0.0     14.58      80.4      9.8
 22    0.0      21.4        81       2.5     .080       0.0       I         R         R        R
 23    0.0    1589.9        31        .4     .060       0.0       I         R         R        R

CYCLE COMPOSITE       HC        8.327    GRAM/BHP HR
                      CO       29.082    GRAM/BHP HR
                      NO2       4.323    GRAM/BHP HR
                      ALDE      0.000    GRAM/BHP HR
                      BSFC       .827      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
 7-28-72 RUN-2   ENG.2-3   1972 VERSION B-CATA W/AIR W/EGR 4 BTDC
-----------------------------------------------------------------------------
             DYNA.        MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED   LOAD    HP   VAC. LB/HR   RATIO   ALDE.    HC      CO      CO2     NO
-----------------------------------------------------------------------------
  1   600      0.0    0  17.5    2.9    23.8       0  2162    .100     8.68     22
  2  1200      5.0    1  10.9   10.1    22.8       0 15447    .210     7.65     15
  3  1200     18.0    4   8.9   12.6    21.5       0  3163    .150     9.64     34
  4  1200     41.0    9   7.5   13.7    20.2       0   645    .130    10.89     73
  5  1200     57.0   13   6.9   14.8    20.0       0   474    .100    11.01    100
  6  1200    115.0   26   5.0   18.0    19.2       0   460    .100    11.60    630
  7  1200    172.0   39   3.3   20.5    18.8       0   527    .100    11.72   1188
  8  1200    189.0   43   2.7   22.7    18.5       0   578    .100    11.92   1800
  9  1200    212.0   48   1.8   24.5    18.0       0   708    .150    12.22   2188
 10  1200    230.0   53    .3   29.2    15.7       0  1265   2.180    11.84   1338
 11   600      0.0    0  18.0    3.2    23.4       0  1354    .280     8.75     35
 12  1200      0.0    0  23.0    3.6    29.1       0 46514    .150     2.26      5
 13  2300    250.0  109    .6   63.7    14.3       0  2794   4.640    10.55    938
 14  2300    230.0  101   2.6   46.1    16.8       0   572    .440    12.71   1825
 15  2300    205.0   90   3.8   42.1    17.1       0   333    .390    12.47   1300
 16  2300    187.0   82   4.5   41.8    17.4       0   221    .350    12.47   1063
 17  2300    125.0   55   7.5   31.3    18.7       0    91    .070    11.84    505
 18  2300     62.0   27  11.8   21.6    21.4       0   389    .100    10.25    255
 19  2300     45.0   20  14.4   19.1    21.2       0   505    .100    10.55    320
 20  2300     20.0    9  15.2   16.2    23.7       0   933    .130     9.03     82
 21  2300      5.0    2  16.5   14.0    24.4       0  1277    .150     8.75     54
 22   600      0.0    0  17.5    3.2    24.7       0  1622    .100     8.68     25
 23  2300      0.0    0  24.7    3.2    42.3       0 47566    .020      .13      3
-----------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
-----------------------------------------------------------------------------
  1    0.0    31.6      30     1.1  .070      0.0     I        R        R       R
  2    0.0   752.5     207     2.4  .060       .1   0.0   658.67    180.9     2.1
  3    0.0   178.9     171     6.4  .060       .2   0.0    43.49     41.7     1.6
  4    0.0    36.1     147    13.5  .050       .5   0.0     3.86     15.7     1.4
  5    0.0    28.5     122    20.0  .030       .4   0.0     2.19      9.3     1.5
  6    0.0    32.0     140   145.4  .060      1.6   0.0     1.22      5.3     5.5
  7    0.0    41.3     158   308.9 0.000      0.0   0.0     1.05      4.0     7.9
  8    0.0    49.3     172   509.5  .040      1.7   0.0     1.14      4.0    11.8
  9    0.0    63.2     271   648.9 0.000      0.0   0.0     1.31      5.6    13.4
 10    0.0   118.5    4123   415.9 0.000      0.0   0.0     2.25     78.5     7.9
 11    0.0    21.4      90     1.8  .070      0.0     I        R        R       R
 12    0.0  1075.6      70      .4  .120      0.0     I        R        R       R
 13    0.0   521.9   17507   581.7  .025      2.7   0.0     4.77    159.9     5.3
 14    0.0    90.6    1407   959.3  .055      5.5   0.0      .90     14.0     4.5
 15    0.0    49.4    1167   639.3  .035      3.1   0.0      .55     13.0     7.1
 16    0.0    32.7    1044   521.1  .060      4.9   0.0      .40     12.7     6.4
 17    0.0    10.8     168   199.7  .060      3.3   0.0      .20      3.1     3.6
 18    0.0    36.7     191    79.8 0.000      0.0   0.0     1.35      7.0     2.9
 19    0.0    40.9     164    86.0  .065      1.3   0.0     2.08      8.3     4.4
 20    0.0    74.1     209    21.6 0.000      0.0   0.0     8.46     23.8     2.5
 21    0.0    89.8     213    12.7 0.000      0.0   0.0    41.03     97.3     5.8
 22    0.0    26.3      33     1.3  .080      0.0     I        R        R       R
 23    0.0  1407.1      12      .3  .060      0.0     I        R        R       R

CYCLE COMPOSITE    HC      12.090    GRAM/BHP HR
                   CO      27.914    GRAM/BHP HR
                   NO2      6.691    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .671      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-1-72  RUN-1 ENG.2-3 72-VER. 8-CATA. W/AIR-W/EGR 4 BTDC
------------------------------------------------------------------------------
           DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED  LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC       CO      CO2    NO
------------------------------------------------------------------------------
  1   600     0.0    0  18.2   3.6   23.1       0  2437     .250    8.75    26
  2  1200     5.0    1  13.5   8.6   19.9       0 25419     .180    6.21    12
  3  1200    18.0    4  10.1  11.5   21.0       0  8441     .210    8.68    22
  4  1200    41.0    9   8.3  13.3   20.3       0  1457     .150   10.66    55
  5  1200    57.0   13   7.3  14.4   19.9       0   625     .100   11.36    85
  6  1200   115.0   26   5.2  16.9   19.4       0   421     .070   11.72   330
  7  1200   172.0   39   3.1  20.5   18.7       0   528     .100   11.92  1225
  8  1200   189.0   43   2.7  21.9   18.5       0   540     .130   12.22  1588
  9  1200   212.0   48   1.8  23.4   18.2       0   630     .130   12.34  2163
 10  1200   230.0   53    .3  29.5   15.3       0  1096    2.210   11.84  1300
 11   600     0.0    0  18.7   3.2   23.2       0  1153     .310    9.14    39
 12  1200     0.0    0  23.0   3.6   25.4       0 39931     .100    2.48    10
 13  2300   252.0  110    .6  63.3   13.3       0  3147    4.540    8.84   838
 14  2300   232.0  102   2.6  48.9   15.9       0   729     .640   12.47  1475
 15  2300   207.0   91   3.9  42.8   17.1       0   302     .390   12.34  1200
 16  2300   189.0   83   4.5  42.1   17.4       0   213     .350   12.59   938
 17  2300   126.0   55   7.7  31.7   18.8       0    81     .070   12.47   535
 18  2300    63.0   28  12.4  20.9   21.5       0   445     .100   10.55   220
 19  2300    45.0   20  13.8  19.4   22.2       0   754     .130    9.93   160
 20  2300    20.0    9  15.6  15.8   23.0       0  1055     .150    9.37    79
 21  2300     5.0    2  17.0  13.7   24.1       0  2136     .150    8.68    44
 22   600     0.0    0  18.2   3.6   24.0       0  1518     .150    8.93    29
 23  2300     0.0    0  24.7   3.2   32.5       0 47535     .020     .06     3
------------------------------------------------------------------------------
         CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO    NO2  FAC.      HP  ALDE.     HC       CO     NO2
------------------------------------------------------------------------------
  1   0.0    43.1      89    1.5  .070     0.0     I       R        R       R
  2   0.0  1110.1     159    1.7  .060      .1   0.0  971.75    139.0     1.5
  3   0.0   452.4     227    3.9  .060      .2   0.0  109.99     55.3     1.0
  4   0.0    80.3     167   10.1  .050      .5   0.0    8.57     17.8     1.1
  5   0.0    35.4     115   16.0  .030      .4   0.0    2.72      8.8     1.2
  6   0.0    27.3      92   71.0  .060     1.6   0.0    1.04      3.5     2.7
  7   0.0    40.7     156  313.3 0.000     0.0   0.0    1.03      4.0     8.0
  8   0.0    43.3     210  422.2  .040     1.7   0.0    1.00      4.9     9.8
  9   0.0    53.4     222  608.2 0.000     0.0   0.0    1.10      4.6    12.6
 10   0.0   103.6    4219  407.9 0.000     0.0   0.0    1.97     80.3     7.8
 11   0.0    17.7      46    2.0  .070     0.0     I       R        R       R
 12   0.0   992.0      50     .8  .120     0.0     I       R        R       R
 13   0.0   659.7   19228  583.3  .025     2.8   0.0    5.98    174.2     5.3
 14   0.0   122.6    2175  824.0  .055     5.6   0.0    1.21     21.4     8.1
 15   0.0    45.9    1199  606.1  .035     3.2   0.0     .51     13.2     6.7
 16   0.0    31.4    1042  459.0  .060     5.0   0.0     .38     12.6     5.5
 17   0.0     4.3     162  203.4  .060     3.3   0.0     .17      2.9     3.7
 18   0.0    39.4     179   64.7 0.000     0.0   0.0    1.43      6.5     2.3
 19   0.0    65.6     228   46.2  .065     1.3   0.0    3.33     11.6     2.3
 20   0.0    78.8     226   19.6 0.000     0.0   0.0    8.99     25.8     2.2
 21   0.0   146.6     208   10.0 0.000     0.0   0.0   66.94     94.9     4.6
 22   0.0    26.8      54    1.7  .080     0.0     I       R        R       R
 23   0.0  1445.3      12     .3  .060     0.0     I       R        R       R

CYCLE COMPOSITE    HC     13.535    GRAM/BHP HR
                   CO     31.393    GRAM/BHP HR
                   NO2     5.746    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .667      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-1-72  RUN-2 ENG.2-3 72-VER. B-CATA. W/AIR-W/EGR 4 BTDC
--------------------------------------------------------------------------------
             DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED   LOAD    HP  VAC. LB/HR  RATIO   ALDE.     HC       CO       CO2     NO
--------------------------------------------------------------------------------
  1   600     0.0     0  18.2   3.3   23.7       0   3570     .150     8.68     25
  2  1200     5.0     1  13.5   8.6   23.8       0 24644     .180     6.30     11
  3  1200    18.0     4  10.0  11.3   22.4       0   8115     .180     8.68     22
  4  1200    41.0     9   8.4  13.5   20.6       0   1364     .150    10.66     55
  5  1200    57.0    13   7.3  14.6   20.1       0    685     .130    11.13     80
  6  1200   115.0    26   5.3  16.9   19.3       0    494     .100    11.84    340
  7  1200   172.0    39   3.3  20.7   18.5       0    579     .130    12.22   1287
  8  1200   189.0    43   2.8  22.5   18.2       0    574     .150    12.22   1550
  9  1200   212.0    48   1.8  23.8   17.6       0    761     .180    12.71   1950
 10  1200   230.0    53    .3  29.9   15.6       0   1211    2.360    11.92   1275
 11   600     0.0     0  18.7   3.5   22.5       0   1142     .350     9.14     35
 12  1200     0.0     0  23.4   3.7   29.6       0 42960     .150     2.32      6
 13  2300   252.0   110    .6  64.3   14.1       0   2629    4.430    10.55    900
 14  2300   232.0   102   2.6  48.8   17.0       0    493     .490    12.47   1862
 15  2300   207.0    91   3.9  42.8   17.2       0    280     .470    12.59   1237
 16  2300   189.0    83   4.5  41.8   17.4       0    186     .420    12.71    988
 17  2300   126.0    55   7.8  31.2   18.6       0     84     .130    12.34    570
 18  2300    63.0    28  12.4  20.9   21.6       0    422     .150    10.35    245
 19  2300    45.0    20  13.8  19.2   22.9       0    622     .150     9.64    177
 20  2300    20.0     9  15.6  15.9   23.7       0    853     .180     9.25     85
 21  2300     5.0     2  17.0  13.7   23.6       0   1528     .250     9.64     49
 22   600     0.0     0  18.2   3.8   23.9       0    975     .180     8.84     34
 23  2300     0.0     0  24.6   3.4   38.9       0 50134     .100      .19      4
--------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO      NO2  FAC.       HP  ALDE.      HC       CO     NO2
--------------------------------------------------------------------------------
  1   0.0    57.3      49      1.3  .070      0.0      I        R        R      R
  2   0.0  1071.0     158      1.6  .060       .1    0.0   937.52   138.3    1.4
  3   0.0   428.2     192      3.9  .060       .2    0.0   104.11    46.6     .9
  4   0.0    76.1     169     10.2  .050       .5    0.0     8.12    18.0    1.1
  5   0.0    34.4     153     15.5  .030       .4    0.0     3.06    11.7    1.2
  6   0.0    31.6     129     72.1  .060      1.6    0.0     1.20     4.9    2.7
  7   0.0    43.8     199    323.5 0.000      0.0    0.0     1.12     5.1    8.2
  8   0.0    47.0     248    421.7  .040      1.7    0.0     1.09     5.7    9.8
  9   0.0    63.4     303    539.7 0.000      0.0    0.0     1.31     6.3   11.1
 10   0.0   114.1    4490    398.7 0.000      0.0    0.0     2.17    85.4    7.6
 11   0.0    18.7     116      1.9  .070      0.0      I        R        R      R
 12   0.0  1062.7      75       .5  .120      0.0      I        R        R      R
 13   0.0   487.0   18444    553.4  .025      2.8    0.0     4.41   167.1    5.0
 14   0.0    83.8    1682   1051.1  .055      5.6    0.0      .82    16.6   10.3
 15   0.0    41.5    1408    609.1  .035      3.2    0.0      .46    15.5    6.7
 16   0.0    26.8    1222    472.3  .060      5.0    0.0      .32    14.8    5.7
 17   0.0     9.5     298    214.8  .060      3.3    0.0      .17     5.4    3.9
 18   0.0    38.6     273     73.2 0.000      0.0    0.0     1.38     9.9    2.7
 19   0.0    55.1     269     52.2  .065      1.3    0.0     2.80    13.6    2.7
 20   0.0    64.7     276     21.4 0.000      0.0    0.0     7.39    31.5    2.4
 21   0.0    94.5     312     10.2 0.000      0.0    0.0    43.15   142.6    4.6
 22   0.0    18.6      69      2.2  .080      0.0      I        R        R      R
 23   0.0  1440.8      58       .4  .060      0.0      I        R        R      R

CYCLE COMPOSITE    HC     13.441    GRAM/BHP HR
                   CO     31.023    GRAM/BHP HR
                   NO2     6.283    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .667      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-2-72  RUN 1 ENG.2-3 72-VER. B-CATA. W/AIR-W/EGR 4 BTDC
-----------------------------------------------------------------------------------------------
           DYNA.          MAN.  FUEL     A/F                DRY CONCENTRATION
MODE SPEED  LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC         CO        CO2      NO
-----------------------------------------------------------------------------------------------
  1    600     0.0    0   18.0    3.6   23.7        0   4052       .180       8.54      23
  2   1200     5.0    1   13.5    8.0   20.8        0  27998       .150       5.96      10
  3   1200    18.0    4   10.1   11.6   21.1        0  11435       .180       8.34      15
  4   1200    41.0    9    8.3   13.5   20.6        0   1619       .130      10.43      44
  5   1200    57.0   13    7.4   14.1   20.2        0    639       .100      10.89      66
  6   1200   115.0   26    5.2   17.3   19.4        0    437       .070      11.48     290
  7   1200   172.0   39    3.2   20.7   18.6        0    556       .100      11.92    1175
  8   1200   189.0   43    2.7   22.1   18.4        0    568       .130      12.09    1525
  9   1200   212.0   48    1.8   23.8   17.9        0    687       .150      12.47    2100
 10   1200   230.0   53     .3   30.3   15.0        0   1174      2.440      11.48    1075
 11    600     0.0    0   18.5    3.6   23.2        0   1087       .390       9.03      37
 12   1200     0.0    0   22.9    3.7   26.3        0  34243       .150       3.08       7
 13   2300   252.0  110     .6   62.4   13.7        0   2272      3.910      10.78     813
 14   2300   232.0  102    2.7   49.1   16.8        0    469       .420      12.22    1675
 15   2300   207.0   91    3.9   43.0   17.0        0    315       .350      12.47    1225
 16   2300   189.0   83    4.5   41.5   17.3        0    224       .350      12.47    1025
 17   2300   126.0   55    7.7   31.2   18.8        0     92       .100      11.92     540
 18   2300    63.0   28   12.4   21.1   21.7        0    391       .100       4.93     230
 19   2300    45.0   20   13.7   19.3   22.6        0    663       .100       9.37     155
 20   2300    20.0    9   15.6   15.9   23.4        0   1085       .130       9.03      76
 21   2300     5.0    2   17.0   13.6   24.4        0   2346       .150       8.34      39
 22    600     0.0    0   18.0    3.6   24.5        0   1319       .130       8.60      28
 23   2300     0.0    0   24.6    3.3   34.0        0  45062       .020        .13       5
-----------------------------------------------------------------------------------------------
           CALCULATED GRAM/HR            WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2     FAC.      HP   ALDE.      HC       CO       NO2
-----------------------------------------------------------------------------------------------
  1    0.0     72.4      65     1.4    .070     0.0     I          R        R        R
  2    0.0   1146.0     124     1.4    .060      .1   0.01003.13       108.6      1.2
  3    0.0    620.0     197     2.7    .060      .2   0.0   150.74      47.9       .7
  4    0.0     42.2     150     8.3    .050      .5   0.0     9.84      16.0       .9
  5    0.0     37.0     117    12.7    .030      .4   0.0     2.84       9.0      1.0
  6    0.0     24.7      96    65.3    .060     1.6   0.0     1.13       3.7      2.5
  7    0.0     43.1     157   302.4   0.000     0.0   0.0     1.10       4.0      7.7
  8    0.0     46.3     214   413.0    .040     1.7   0.0     1.07       5.0      9.6
  9    0.0     58.4     258   592.7   0.000     0.0   0.0     1.21       5.3     12.2
 10    0.0    114.9    4826   349.4   0.000     0.0   0.0     2.19      91.8      6.6
 11    0.0     18.7     135     2.1    .070     0.0     I          R        R        R
 12    0.0    859.0      76      .6    .120     0.0     I          R        R        R
 13    0.0    430.8   14477   511.8    .025     2.8   0.0     3.90     135.7      4.6
 14    0.0     82.4    1490   976.6    .055     5.6   0.0      .81      14.7      9.6
 15    0.0     47.4    1074   617.5    .035     3.2   0.0      .53      11.8      6.8
 16    0.0     32.5    1037   499.1    .060     5.0   0.0      .40      12.5      6.0
 17    0.0     10.9     238   211.2    .060     3.3   0.0      .20       4.3      3.8
 18    0.0     37.2     192    72.5   0.000     0.0   0.0     1.35       7.0      2.6
 19    0.0     60.4     186    47.3    .065     1.3   0.0     3.09       9.4      2.4
 20    0.0     84.2     204    19.6   0.000     0.0   0.0     9.62      23.3      2.2
 21    0.0    165.9     214     9.2   0.000     0.0   0.0    75.75      97.8      4.2
 22    0.0     24.2      48     1.7    .080     0.0     I          R        R        R
 23    0.0   1470.6      13      .5    .060     0.0     I          R        R        R
CYCLE COMPOSITE    HC      13.247     GRAM/BHP HR
                   CO      25.626     GRAM/BHP HR
                   NO2      6.095     GRAM/BHP HR
                   ALDE     0.000     GRAM/BHP HR
                   BSFC      .666       LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-28-72 RUN-1    ENG.2-3   1972 VERSION-  A-CATA W/AIR W/EGR 4 ATDC
-------------------------------------------------------------------------------
                 DYNA.         MAN.  FUEL    A/F              DRY CONCENTRATION
MODE SPEED       LOAD    HP   VAC.  LB/HR   RATIO    ALDE.     HC      CO       CO2     NO
-------------------------------------------------------------------------------
  1    600        0.0     0   16.5    4.0    22.4        0    191    .020      9.64     37
  2   1200        4.0     1   10.0   11.2    23.5        0   1132    .050      9.50     18
  3   1200       15.0     3    8.7   12.6    21.2        0    350    .020     10.25     27
  4   1200       33.0     8    6.9   14.8    19.5        0     80    .070     11.48     69
  5   1200       46.0    11    6.1   15.1    19.5        0     53    .050     11.48     96
  6   1200       92.0    21    4.4   18.7    19.2        0     83    .050     11.72    340
  7   1200      138.0    32    2.9   21.2    18.3        0     60    .050     12.09    470
  8   1200      151.0    35    2.3   22.3    18.4        0     86    .020     12.09   1125
  9   1200      169.0    39    1.4   23.4    17.9        0     84    .070     12.71   1150
 10   1200      184.0    42     .3   29.2    15.1        0    191   2.020     13.18    600
 11    600        0.0     0   17.0    5.0    21.8        0     57    .150      9.93     60
 12   1200        0.0     0   21.1    5.8    25.4        0   1240    .150      8.34     26
 13   2300      222.0    97     .6   63.0    13.8        0    609   3.790     12.34    545
 14   2300      204.0    89    2.6   50.8    16.1        0     45    .100     13.91    850
 15   2300      182.0    80    3.6   41.8    16.8        0     36    .050     13.63    675
 16   2300      166.0    73    4.2   42.8    17.3        0     39    .050     13.33    610
 17   2300      111.0    49    6.6   34.6    18.5        0     34    .050     12.34    370
 18   2300       55.0    24   10.0   25.2    20.7        0     53    .050     10.55    140
 19   2300       40.0    18   12.4   20.9    22.9        0     63    .050     10.09    113
 20   2300       18.0     8   15.3   16.6    24.6        0    149    .020      9.14     55
 21   2300        4.0     2   17.0   15.5    22.6        0     52    .020      9.93     83
 22    600        0.0     0   16.5    4.0    23.9        0    293    .020      9.14     41
 23   2300        0.0     0   24.4    3.6    50.6        0   9271    .050      3.20      3
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR           WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO      NO2   FAC.       HP  ALDE.      HC       CO      NO2
-------------------------------------------------------------------------------
  1    0.0     3.5       7      2.3  .070       0.0      I       R        R        R
  2    0.0    59.3      53      3.0  .060        .1    0.0   64.88     57.9      3.3
  3    0.0    19.4      22      5.0  .060        .2    0.0    5.67      6.5      1.5
  4    0.0     4.6      82     13.4  .050        .4    0.0     .62     10.9      1.8
  5    0.0     3.1      60     19.0  .030        .3    0.0     .30      5.7      1.8
  6    0.0     6.0      73     81.4  .060       1.3    0.0     .29      3.5      3.9
  7    0.0     4.7      80    123.[illegible] 0.000       0.0    0.0     .15      2.5      3.9
  8    0.0     7.2      34    312.0  .040       1.4    0.0     .21      1.0      9.0
  9    0.0     7.0     117    316.9 0.000       0.0    0.0     .18      3.0      8.2
 10    0.0    16.6    3546    173.1 0.000       0.0    0.0     .39     84.4      4.1
 11    0.0     1.3      69      4.5  .070       0.0      I       R        R        R
 12    0.0    37.6      92      2.6  .120       0.0      I       R        R        R
 13    0.0   107.5   13512    319.4  .025       2.4    0.0    1.11    139.0      3.3
 14    0.0     7.3     332    463.6  .055       4.9    0.0     .08      3.7      5.2
 15    0.0     5.0     140    310.2  .035       2.8    0.0     .06      1.8      3.9
 16    0.0     5.7     147    294.0  .060       4.4    0.0     .08      2.0      4.0
 17    0.0     4.4     128    155.4  .060       2.9    0.0     .09      2.6      3.2
 18    0.0     5.8     109     50.1 0.000       0.0    0.0     .24      4.5      2.1
 19    0.0     5.9      94     34.9  .065       1.1    0.0     .34      5.4      2.0
 20    0.0    12.2      33     14.9 0.000       0.0    0.0    1.55      4.2      1.9
 21    0.0     3.7      28     19.6 0.000       0.0    0.0    2.09     16.3     11.2
 22    0.0     5.7       8      2.7  .080       0.0      I       R        R        R
 23    0.0   362.4      39       .3  .060       0.0      I       R        R        R

CYCLE COMPOSITE     HC      1.671    GRAM/BHP HR
                    CO     18.923    GRAM/BHP HR
                    NO2     4.230    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .827      LB/BHP HR
```

```
                PROJECT 11-2877-01  CONTROL TECHNOLOGY
  7-28-72 RUN-2   ENG.2-3   1972 VERSION A-CATA W/AIR W/EGR 4 BTDC
--------------------------------------------------------------------------
             DYNA.         MAN. FUEL    A/F            DRY CONCENTRATION
MODE SPEED   LOAD    HP   VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2     NO
--------------------------------------------------------------------------
  1    600     0.0     0  17.5   2.9   24.6       0   675    .050     8.68     25
  2   1200     5.0     1  10.9  10.1   23.7       0  2545    .020     8.93     19
  3   1200    18.0     4   8.9  12.6   21.6       0   574    .050    10.09     42
  4   1200    41.0     9   7.5  13.7   20.6       0   171    .050    10.78     74
  5   1200    57.0    13   6.9  14.8   20.2       0   125    .070    11.01    103
  6   1200   115.0    26   5.0  18.0   19.5       0   151    .070    11.48    704
  7   1200   172.0    39   3.3  20.5   19.2       0   188    .100    11.60   1225
  8   1200   189.0    43   2.7  22.7   18.6       0   211    .100    11.92   1875
  9   1200   212.0    48   1.8  24.5   18.2       0   243    .100    12.22   2013
 10   1200   230.0    53    .3  29.2   15.5       0   713   1.520    12.71   1000
 11    600     0.0     0  18.0   3.2   24.6       0   406    .050     8.75     31
 12   1200     0.0     0  23.0   3.6   35.6       0  3104    .150     5.50      6
 13   2300   250.0   109    .6  63.7   13.8       0  1152   4.070    10.78    950
 14   2300   230.0   101   2.6  46.1   17.1       0    95    .050    12.94   1738
 15   2300   205.0    90   3.8  42.1   17.0       0    66    .050    12.94   1275
 16   2300   187.0    82   4.5  41.8   17.4       0    56    .050    12.71   1113
 17   2300   125.0    55   7.5  31.3   19.1       0    52    .020    11.92    590
 18   2300    62.0    27  11.8  21.6   21.8       0    82    .020    10.25    245
 19   2300    45.0    20  14.4  19.1   21.4       0    80    .020    10.55    300
 20   2300    20.0     9  15.2  16.2   24.1       0   179    .020     9.14     83
 21   2300     5.0     2  16.5  14.0   24.7       0   297    .020     8.75     59
 22    600     0.0     0  17.5   3.2   25.5       0   318    .050     8.60     27
 23   2300     0.0     0  24.7   3.2   56.9       0  6239    .050     3.08      2
--------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.      HP  ALDE.      HC      CO     NO2
--------------------------------------------------------------------------
  1    0.0   10.1      15     1.2  .070     0.0      I       R       R       R
  2    0.0  126.7      20     3.1  .060      .1    0.0  110.86    17.6     2.7
  3    0.0   32.2      57     7.8  .060      .2    0.0    7.83    13.8     1.9
  4    0.0    9.8      58    14.1  .050      .5    0.0    1.04     6.2     1.5
  5    0.0    7.5      86    20.7  .030      .4    0.0     .58     6.6     1.6
  6    0.0   10.6     100   165.0  .060     1.6    0.0     .40     3.8     6.3
  7    0.0   14.9     160   322.7 0.000     0.0    0.0     .38     4.1     8.2
  8    0.0   18.1     173   532.3  .040     1.7    0.0     .42     4.0    12.3
  9    0.0   21.9     182   601.7 0.000     0.0    0.0     .45     3.8    12.4
 10    0.0   66.0    2844   307.5 0.000     0.0    0.0    1.26    54.1     5.9
 11    0.0    6.7      17     1.7  .070     0.0      I       R       R       R
 12    0.0   85.0      83      .5  .120     0.0      I       R       R       R
 13    0.0  222.5   15874   609.0  .025     2.7    0.0    2.03   145.0     5.6
 14    0.0   15.3     162   928.2  .055     5.5    0.0     .15     1.6     9.2
 15    0.0    9.7     148   622.0  .035     3.1    0.0     .11     1.7     6.9
 16    0.0    8.3     150   548.8  .060     4.9    0.0     .10     1.8     6.7
 17    0.0    6.2      48   232.8  .060     3.3    0.0     .11      .9     4.3
 18    0.0    7.8      39    77.5 0.000     0.0    0.0     .29     1.4     2.9
 19    0.0    6.6      33    81.6  .065     1.3    0.0     .33     1.7     4.1
 20    0.0   14.3      32    22.1 0.000     0.0    0.0    1.64     3.7     2.5
 21    0.0   21.5      29    14.1 0.000     0.0    0.0    9.80    13.3     6.5
 22    0.0    5.3      17     1.5  .080     0.0      I       R       R       R
 23    0.0  241.2      39      .3  .060     0.0      I       R       R       R

CYCLE COMPOSITE     HC      1.810    GRAM/BHP HR
                    CO     18.278    GRAM/BHP HR
                    NO2     6.850    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .671      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-1-72  RUN-1 ENG.2-3 72-VER. A-CATA. W/AIR-W/EGR 4 BTDC
--------------------------------------------------------------------------------------
            DYNA.        MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED   LOAD    HP  VAC. LB/HR   RATIO    ALDE.    HC      CO       CO2      NO
--------------------------------------------------------------------------------------
  1   600     0.0     0  18.2   3.6   23.9       22    636    .020      8.84      50
  2  1200     5.0     1  13.5   8.6   23.6       37   3375    .050      8.60      18
  3  1200    18.0     4  10.1  11.5   22.3       48   1305    .050      9.37      50
  4  1200    41.0     9   8.3  13.3   20.5       37    268    .050     10.78      65
  5  1200    57.0    13   7.3  14.4   20.1       23    143    .020     11.13      32
  6  1200   115.0    26   5.2  16.9   19.6       28    116    .020     11.48     325
  7  1200   172.0    39   3.1  20.5   18.9       12    181    .020     11.92    1375
  8  1200   189.0    43   2.7  21.9   18.6       16    189    .020     12.09    1700
  9  1200   212.0    48   1.8  23.4   18.3       13    209    .020     12.34    2037
 10  1200   230.0    53    .3  29.5   15.7       21    510   1.520     12.94    1000
 11   600     0.0     0  18.7   3.2   24.0        6    244    .020      9.03      37
 12  1200     0.0     0  23.0   3.6   35.4       27   3943    .050      5.50      12
 13  2300   252.0   110    .6  63.3   14.0       24   1242   3.790     11.60     875
 14  2300   232.0   102   2.6  48.9   16.2       18    163    .150     13.48    1325
 15  2300   207.0    91   3.9  42.8   17.2        6     57    .050     12.94    1175
 16  2300   189.0    83   4.5  42.1   17.6        6     43    .050     12.82    1000
 17  2300   126.0    55   7.7  31.7   18.9        7     43    .050     12.22     580
 18  2300    63.0    28  12.4  20.9   21.6        3     93    .050     10.55     190
 19  2300    45.0    20  13.8  19.4   22.4        7    137    .050      9.93     143
 20  2300    20.0     9  15.6  15.8   23.6        6    206    .020      9.25      79
 21  2300     5.0     2  17.0  13.7   24.6       12    541    .020      8.84      68
 22   600     0.0     0  18.2   3.6   24.6       11    379    .020      8.84      30
 23  2300     0.0     0  24.7   3.2   52.1       43   6567    .050      3.20       2
--------------------------------------------------------------------------------------
       CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC      CO     NO2
--------------------------------------------------------------------------------------
  1     .9   11.6        7     3.0  .070     0.0      R       R       R       R
  2    3.4  146.5       44     2.6  .060      .1    3.0  128.23    38.4     2.3
  3    5.6   71.3       55     9.1  .060      .2    1.4   17.33    13.4     2.2
  4    4.5   14.9       56    12.0  .050      .5     .5    1.59     6.0     1.3
  5    2.9    8.4       24     6.2  .030      .4     .2     .64     1.8      .5
  6    4.1    7.7       27    71.9  .060     1.6     .2     .29     1.0     2.7
  7    2.0   14.1       31   355.0 0.000     0.0     .1     .36      .8     9.0
  8    2.8   15.5       33   462.3  .040     1.7     .1     .36      .8    10.7
  9    2.4   18.0       35   579.8 0.000     0.0     .0     .37      .7    12.0
 10    4.3   47.0     2831   306.2 0.000     0.0     .1     .90    53.9     5.8
 11     .2    3.9        7     2.0  .070     0.0      R       R       R       R
 12    1.6  108.3       28     1.1  .120     0.0      R       R       R       R
 13    9.8  229.8    14169   537.6  .025     2.8     .1    2.08   128.4     4.9
 14    6.5   26.5      493   715.0  .055     5.6     .1     .26     4.8     7.0
 15    1.8    8.5      151   582.8  .035     3.2     .0     .09     1.7     6.4
 16    2.1    6.3      150   492.7  .060     5.0     .0     .08     1.8     6.0
 17    1.9    5.1      118   225.4  .060     3.3     .0     .09     2.1     4.1
 18     .5    8.3       90    56.3 0.000     0.0     .0     .30     3.3     2.0
 19    1.4   12.0       89    41.9  .065     1.3     .1     .61     4.5     2.1
 20    1.0   16.0       31    20.3 0.000     0.0     .1    1.82     3.6     2.3
 21    1.7   37.7       28    15.7 0.000     0.0     .8   17.20    12.8     7.2
 22     .4    6.9        7     1.8  .080     0.0      R       R       R       R
 23    3.5  247.0       38      .2  .060     0.0      R       R       R       R

CYCLE COMPOSITE      HC      2.097    GRAM/BHP HR
                     CO     16.749    GRAM/BHP HR
                     NO2     5.631    GRAM/BHP HR
                     ALDE     .106    GRAM/BHP HR
                     BSFC     .667      LB/BHP HR
```

```
                                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-1-72  RUN-2 ENG.2-3 72-VER. A-CATA. W/AIR-W/EGR 4 BTDC
------------------------------------------------------------------------------------------
                   DYNA.            MAN. FUEL    A/F                 DRY CONCENTRATION
 MODE SPEED        LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC        CO        CO2      NO
------------------------------------------------------------------------------------------
    1   600         0.0      0   18.2    3.3   24.8       28    1351      .020       8.68      28
    2  1200         5.0      1   13.5    8.6   24.9       37    4043      .020       8.43      15
    3  1200        18.0      4   10.0   11.3   23.3       67    1741      .020       9.50      28
    4  1200        41.0      9    8.4   13.5   21.0       36     324      .050      10.66      63
    5  1200        57.0     13    7.3   14.6   20.3       23     154      .050      11.13      83
    6  1200       115.0     26    5.3   16.9   19.7       24     133      .050      11.60     325
    7  1200       172.0     39    3.3   20.7   18.9       26     217      .050      12.09    1312
    8  1200       189.0     43    2.8   22.5   18.5       17     220      .050      12.09    1675
    9  1200       212.0     48    1.8   23.8   18.1       16     257      .050      12.47    1800
   10  1200       230.0     53     .3   29.9   15.4       15     670     1.660      12.94    1000
   11   600         0.0      0   18.7    3.5   24.0        7     271      .050       8.93      34
   12  1200         0.0      0   23.4    3.7   36.0       27    4789      .100       5.27       5
   13  2300       252.0    110     .6   64.3   13.8       31    1146     4.070      11.72     888
   14  2300       232.0    102    2.6   48.8   16.6       15     112      .100      13.33    1750
   15  2300       207.0     91    3.9   42.8   17.0       11      58      .100      13.18    1225
   16  2300       189.0     83    4.5   41.8   17.3        6      42      .100      13.06    1025
   17  2300       126.0     55    7.8   31.2   19.0        8      45      .070      12.09     650
   18  2300        63.0     28   12.4   20.9   21.7        5      77      .130      10.43     215
   19  2300        45.0     20   13.8   19.2   22.8        7      97      .070       9.93     170
   20  2300        20.0      9   15.6   15.9   24.1        7     133      .070       9.25      90
   21  2300         5.0      2   17.0   13.7   24.9       12     332      .070       8.68      54
   22   600         0.0      0   18.2    3.8   24.9       10     195      .070       8.75      35
   23  2300         0.0      0   24.6    3.4   52.3       49    5160      .150       3.31       3
------------------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
 MODE ALDE.     HC      CO     NO2  FAC.       HP   ALDE.      HC        CO       NO2
------------------------------------------------------------------------------------------
    1   1.0    22.5      7     1.5  .070      0.0       R        R         R         R
    2   3.5   177.5     18     2.2  .060       .1     3.1   155.38      15.5       1.9
    3   7.6    91.6     21     5.0  .060       .2     1.9    22.28       5.2       1.2
    4   4.4    18.4     57    12.0  .050       .5      .5     1.97       6.1       1.3
    5   2.9     4.1     60    16.1  .030       .4      .2      .70       4.6       1.2
    6   3.4     8.7     66    70.9  .060      1.6      .1      .33       2.5       2.7
    7   4.3    16.7     78   336.3 0.000      0.0      .1      .43       2.0       8.6
    8   3.1    18.4     85   465.6  .040      1.7      .1      .43       2.0      10.8
    9   2.9    22.1     87   514.9 0.000      0.0      .1      .46       1.8      10.6
   10   3.0    61.4   3101   307.0 0.000      0.0      .1     1.18      59.0       5.8
   11    .3     4.7     18     2.0  .070      0.0       R        R         R         R
   12   1.7   137.0     58      .5  .120      0.0       R        R         R         R
   13  12.2   210.1  15072   540.2  .025      2.8      .1     1.90     136.6       4.9
   14   5.3    18.5    332   955.8  .055      5.6      .1      .18       3.3       9.4
   15   3.5     8.4    295   594.0  .035      3.2      .0      .09       3.3       6.6
   16   1.7     6.1    291   489.7  .060      5.0      .0      .07       3.5       5.9
   17   2.1     5.3    165   251.2  .060      3.3      .0      .10       3.0       4.6
   18   1.1     6.9    236    64.1 0.000      0.0      .0      .25       8.5       2.3
   19   1.4     8.5    123    49.2  .065      1.3      .1      .43       6.3       2.5
   20   1.2    10.3    109    23.1 0.000      0.0      .1     1.17      12.5       2.6
   21   1.8    23.5    100    12.7 0.000      0.0      .8    10.73      45.7       5.8
   22    .4     3.8     28     2.3  .080      0.0       R        R         R         R
   23   4.1   197.8    116      .4  .060      0.0       R        R         R         R

CYCLE COMPOSITE     HC       2.227    GRAM/BHP HR
                    CO      18.506    GRAM/BHP HR
                    NO2      6.238    GRAM/BHP HR
                    ALDE      .114    GRAM/BHP HR
                    BSFC      .667      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-2-72  RUN 1 ENG.2-3 72-VER. A-CATA. W/AIR-W/EGR 4 BTDC
-----------------------------------------------------------------------------
               DYNA.           MAN.  FUEL     A/F                  DRY CONCENTRATION
MODE  SPEED    LOAD      HP    VAC.  LB/HR   RATIO    ALDE.    HC        CO        CO2      NO
-----------------------------------------------------------------------------
  1     600      0.0      0    18.0    3.6    24.7       19   1214      .020      8.54      25
  2    1200      5.0      1    13.5    8.0    25.1       40   4306      .020      8.24      14
  3    1200     18.0      4    10.1   11.6    22.9       45   1737      .020      9.25      22
  4    1200     41.0      9     8.3   13.5    20.9       40    302      .020     10.55      55
  5    1200     57.0     13     7.4   14.1    20.3       22    198      .020     10.89      70
  6    1200    115.0     26     5.2   17.3    19.8       31    132      .020     11.01     270
  7    1200    172.0     39     3.2   20.7    18.8       18    200      .020     11.72    1150
  8    1200    189.0     43     2.7   22.1    18.6       18    211      .050     11.72    1600
  9    1200    212.0     48     1.8   23.8    18.1       19    225      .050     12.34    1925
 10    1200    230.0     53      .3   30.3    15.4       26    600     1.870     12.47     875
 11     600      0.0      0    18.5    3.6    24.0       13    260      .050      8.93      35
 12    1200      0.0      0    22.9    3.7    34.0       27   5394      .050      5.63       6
 13    2300    252.0    110      .6   62.4    14.2       22    841     3.060     12.22     925
 14    2300    232.0    102     2.7   49.1    17.0       17    112      .050     12.94    1675
 15    2300    207.0     91     3.9   43.0    17.2        9     63      .050     12.94    1275
 16    2300    189.0     83     4.5   41.5    17.4        8     48      .050     12.94    1025
 17    2300    126.0     55     7.7   31.2    19.0        5     51      .020     11.72     600
 18    2300     63.0     28    12.4   21.1    21.8        6     84      .020     10.09     190
 19    2300     45.0     20    13.7   19.3    22.7        9    114      .020      9.50     153
 20    2300     20.0      9    15.6   15.9    23.8        9    195      .020      9.03      79
 21    2300      5.0      2    17.0   13.6    24.8        9    513      .020      8.60      44
 22     600      0.0      0    18.0    3.6    25.1        9    302      .020      8.54      30
 23    2300      0.0      0    24.6    3.3    53.3       38   6432      .020      3.13       3
-----------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP   ALDE.     HC       CO     NO2
-----------------------------------------------------------------------------
  1     .8    23.0       8     1.6   .070     0.0      R        R        R       R
  2    3.6   180.7      17     2.0   .060      .1    3.2   158.16     14.8     1.7
  3    5.4    96.4      22     4.1   .060      .2    1.3    23.43      5.4     1.0
  4    5.0    17.4      23    10.5   .050      .5     .5     1.86      2.5     1.1
  5    2.8    11.6      24    13.6   .030      .4     .2      .89      1.8     1.0
  6    4.7     9.4      29    63.8   .060     1.6     .2      .36      1.1     2.4
  7    3.2    15.9      32   304.4  0.000     0.0     .1      .40       .8     7.7
  8    3.4    17.9      86   451.2   .040     1.7     .1      .41      2.0    10.4
  9    3.6    19.6      88   555.4  0.000     0.0     .1      .40      1.8    11.5
 10    5.4    57.3    3605   277.3  0.000     0.0     .1     1.09     68.6     5.3
 11     .5     4.7      18     2.1   .070     0.0      R        R        R       R
 12    1.6   144.8      27      .5   .120     0.0      R        R        R       R
 13    8.6   154.9   11380   565.4   .025     2.8     .1     1.40    103.1     5.1
 14    6.2    19.2     173   953.0   .055     5.6     .1      .19      1.7     9.4
 15    3.0     9.4     152   635.6   .035     3.2     .0      .10      1.7     7.0
 16    2.4     7.0     146   493.2   .060     5.0     .0      .08      1.8     6.0
 17    1.2     6.2      49   240.3   .060     3.3     .0      .11       .9     4.4
 18    1.3     8.0      38    59.6  0.000     0.0     .0      .29      1.4     2.2
 19    1.8    10.5      37    46.7   .065     1.3     .1      .53      1.9     2.4
 20    1.5    15.5      32    20.8  0.000     0.0     .2     1.77      3.7     2.4
 21    1.4    36.5      29    10.4  0.000     0.0     .6    16.66     13.1     4.7
 22     .4     5.7       8     1.9   .080     0.0      R        R        R       R
 23    3.3   257.7      16      .4   .060     0.0      R        R        R       R

CYCLE COMPOSITE    HC      2.340   GRAM/BHP HR
                   CO     12.893   GRAM/BHP HR
                   NO2     6.242   GRAM/BHP HR
                   ALDE     .109   GRAM/BHP HR
                   BSFC     .666     LB/BHP HR
```

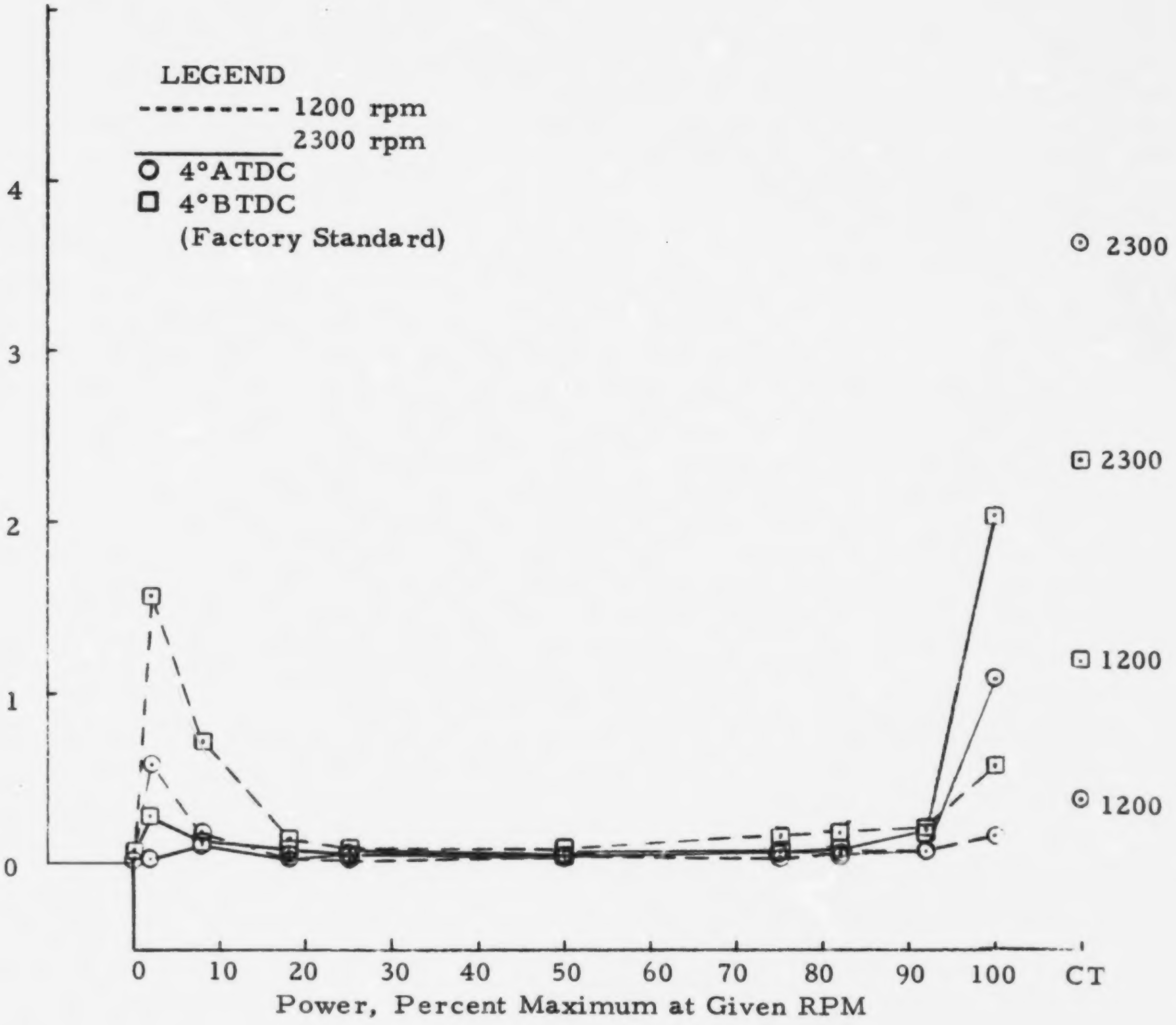


FIGURE O-1. EFFECT OF POWER ON HC EMISSION RATE - "BEST COMBINATION", ENGINE 2-3, 23 MODE TEST

BLANK

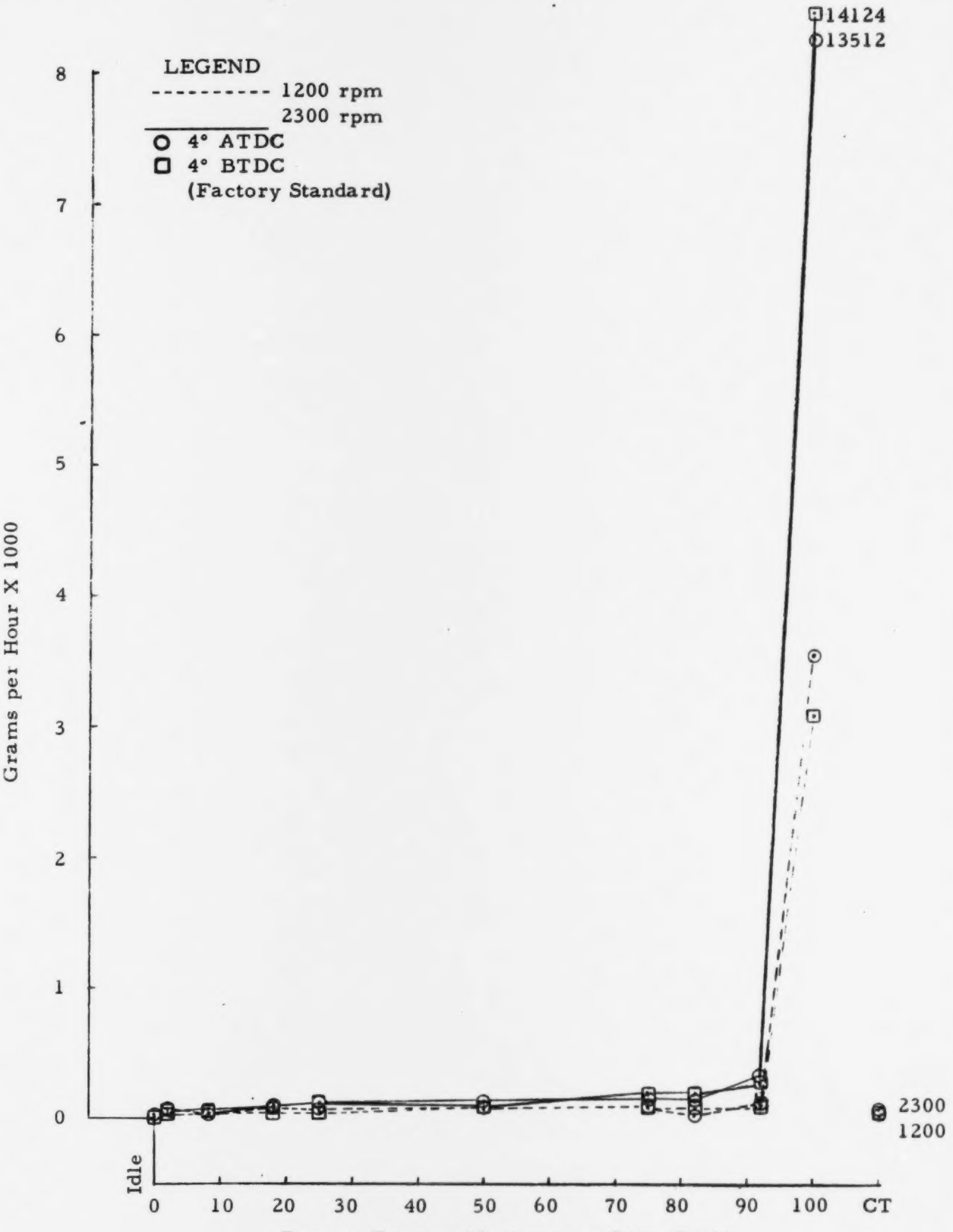


FIGURE 0-2. EFFECT OF POWER ON CO EMISSION RATE - "BEST COMBINATION", ENGINE 2-3, 23 MODE TEST

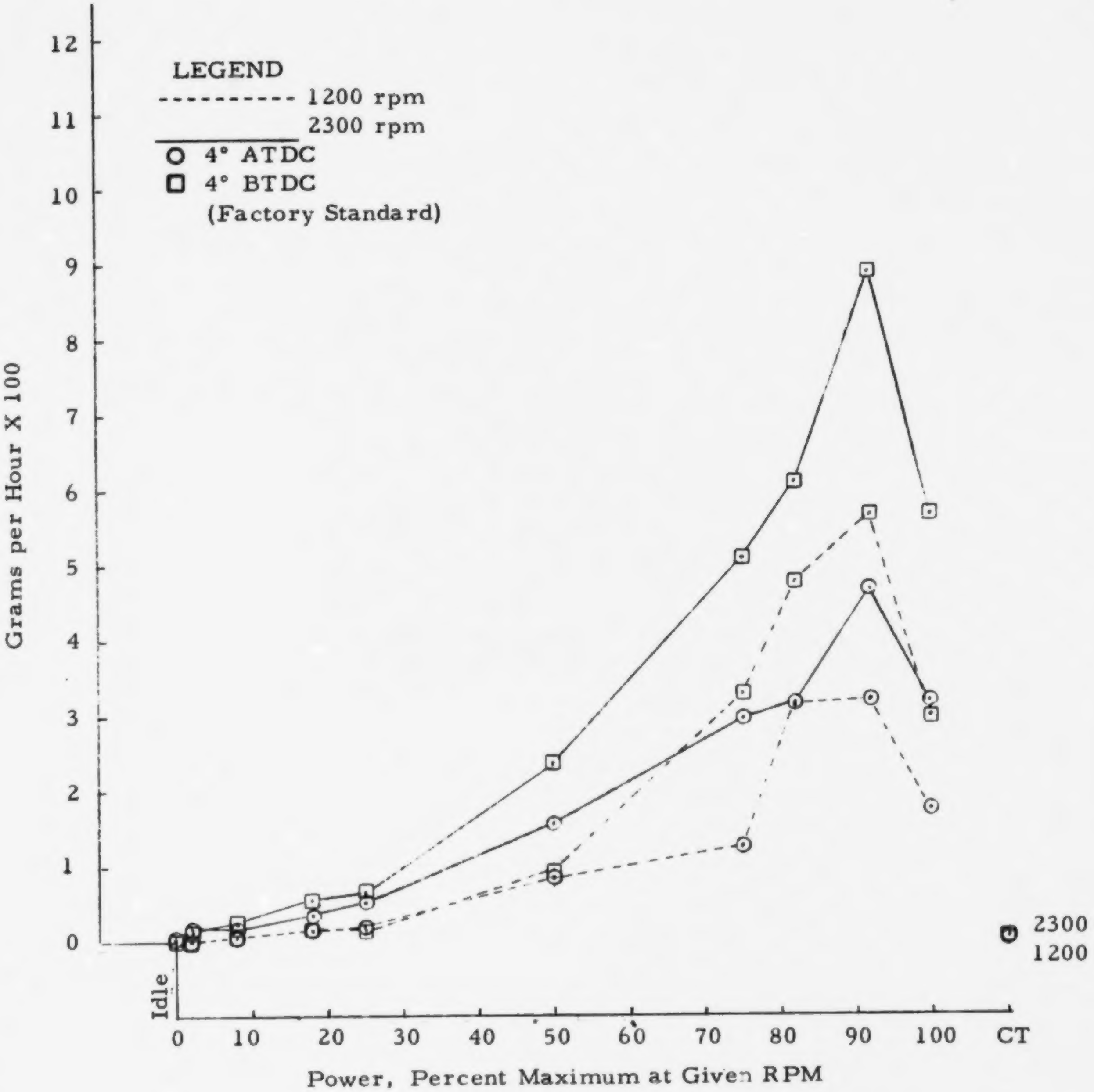


FIGURE 0-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE - "BEST COMBINATION", ENGINE 2-3, 23 MODE TEST

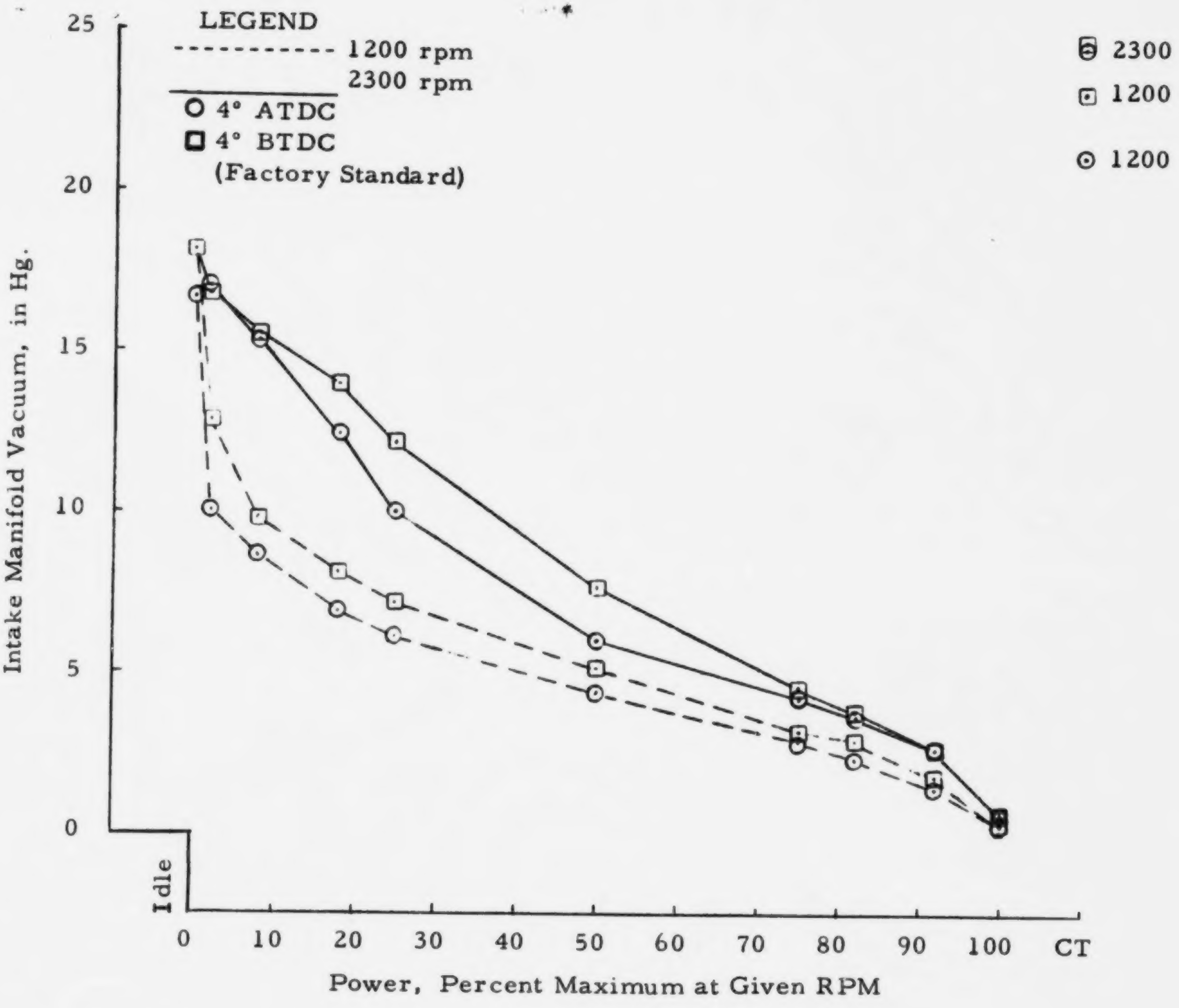


FIGURE 0-4. MANIFOLD VACUUM AS A FUNCTION OF POWER - "BEST COMBINATION", ENGINE 2-3, 23 MODE TEST

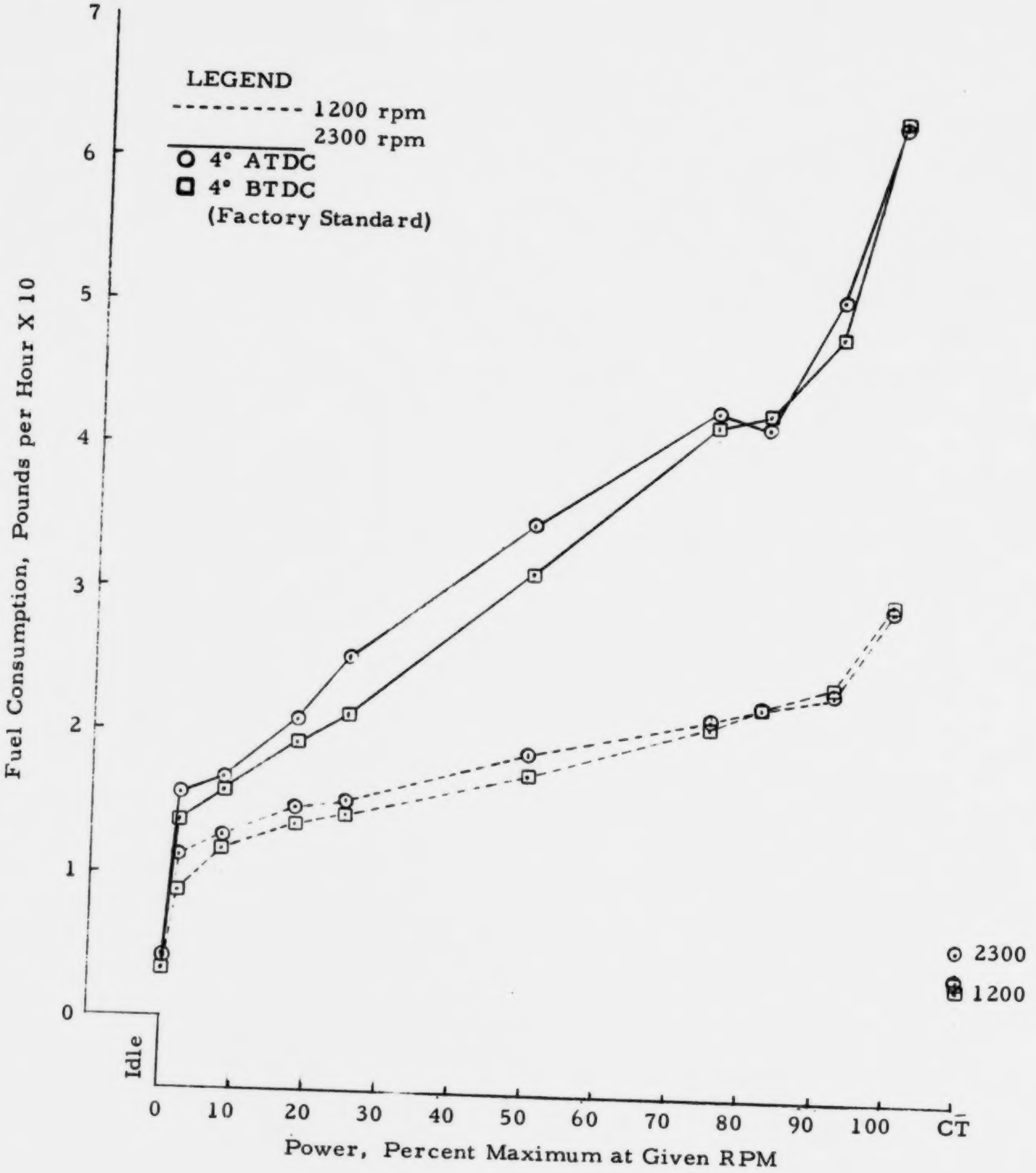


FIGURE 0-5. FUEL CONSUMPTION AS A FUNCTION OF POWER - "BEST COMBINATION", ENGINE 2-3, 23 MODE TEST

ENGINE 2-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

TABULAR NINE-MODE FTP DATA

CONCENTRATION AND CALIFORNIA ARB MASS

ENGINE 2-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

GRAPHED RESULTS OF 23 MODE TESTS
(AFTER CATALYST)

```
   8-2-72  RUN-2 2-3 4BTDC 600 RPM W/AIR EGR  OXIDATION CATALYST       K =1.051      HUM =  90  GR/LB
   ---------------------------------------------------------------------------------------------------------------
   FEDERAL      CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D    WEIGHTING      W E I G H T E D
   MODE          HC      CO    CO2     NO     FACTOR      HC     CO     NO     FACTOR       HC       CO       NO
   ---------------------------------------------------------------------------------------------------------------
CYCLE 1
   1 IDLE        21    .050   8.750    64     1.648       35   .082    105     .036       1.246    .003     3.797
   2 16'HG      239    .050   8.600    64     1.632      390   .082    104     .089      34.721    .007     9.298
   3 10'HG       13    .050  10.430   157     1.385       18   .069    217     .257       4.627    .018    55.885
   4 16'HG       49    .050   8.840    90     1.626       80   .081    146     .089       7.091    .007    13.024
   5 19'HG      573    .050   7.000    57     1.897     1087   .095    108     .047      51.087    .004     5.082
   6 16'HG       63    .050   8.840    64     1.623      102   .081    104     .089       9.101    .007     9.246
   7  3'HG        4    .070  13.060  1463     1.107        4   .077   1619     .283       1.253    .022   458.300
   8 16'HG        4    .050   9.140   112     1.581        6   .079    177     .089        .563    .007    15.763
   9 C.T.       293    .060   4.930    63     2.748      805   .165    173     .021      16.909    .003     3.636
   SUM-------⊙---(CYCLE COMPOSITE)-------------------------------------------------    126.598    .079   574.030
CYCLE 2
   1 IDLE        21    .050   8.750    64     1.648       35   .082    105     .036       1.246    .003     3.797
   2 16'HG      113    .050   8.840    90     1.613      182   .081    145     .089      16.226    .007    12.924
   3 10'HG        4    .050  10.660   210     1.356        5   .068    285     .257       1.394    .017    73.210
   4 16'HG       48    .050   8.930    96     1.610       77   .080    155     .089       6.877    .007    13.755
   5 19'HG      625    .050   6.820    64     1.928     1205   .096    123     .047      56.641    .005     5.800
   6 16'HG       62    .050   8.930    64     1.607      100   .080    103     .089       8.868    .007     9.155
   7  3'HG        4    .070  12.940  1559     1.117        4   .078   1742     .283       1.265    .022   492.888
   8 16'HG        9    .050   9.140   108     1.580       14   .079    171     .089       1.266    .007    15.191
   9 C.T.       295    .050   4.590    65     2.939      867   .147    191     .021      18.207    .003     4.012
   SUM-----------(CYCLE COMPOSITE)-------------------------------------------------    111.991    .079   630.732
CYCLE 3
   1 IDLE         4    .020   8.840    70     1.638        7   .033    115     .036        .236    .001     4.127
   2 16'HG      111    .020   8.840    90     1.617      179   .032    145     .089      15.970    .003    12.948
   3 10'HG        4    .050  10.510   190     1.376        6   .069    261     .257       1.414    .018    67.180
   4 16'HG       37    .050   8.930    97     1.612       60   .081    156     .089       5.308    .007    13.917
   5 19'HG      590    .050   7.090    71     1.870     1104   .094    133     .047      51.867    .004     6.242
   6 16'HG       50    .050   9.030    77     1.592       80   .080    123     .089       7.084    .007    10.909
   7  3'HG        4    .070  13.060  1579     1.107        4   .077   1748     .283       1.253    .022   494.638
   8 16'HG        6    .020   9.180   108     1.577        9   .032    170     .089        .842    .003    15.155
   9 C.T.       296    .060   4.580    65     2.941      871   .176    194     .021      18.284    .004     4.077
   SUM-----------(CYCLE COMPOSITE)-------------------------------------------------    102.258    .069   629.193
CYCLE 4
   1 IDLE         4    .050   8.840    70     1.635        7   .082    114     .036        .235    .003     4.120
   2 16'HG       88    .050   8.840    90     1.618      142   .081    146     .089      12.674    .007    12.963
   3 10'HG        4    .050  10.550   197     1.371        5   .069    270     .257       1.409    .018    69.392
   4 16'HG       40    .050   8.840   103     1.628       65   .081    168     .089       5.795    .007    14.921
   5 19'HG      588    .050   6.910    71     1.915     1126   .096    136     .047      52.935    .005     6.392
   6 16'HG       51    .020   8.930    77     1.612       82   .032    124     .089       7.317    .003    11.047
   7  3'HG        4    .070  12.940  1579     1.117        4   .078   1764     .283       1.265    .022   494.212
   8 16'HG        9    .050   9.140   117     1.580       14   .079    185     .089       1.266    .007    16.457
   9 C.T.       301    .060   4.560    68     2.950      888   .177    201     .021      18.648    .004     4.213
   SUM-----------(CYCLE COMPOSITE)-------------------------------------------------    101.544    .075   638.716

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------    119.295    .079   602.381

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------    101.901    .072   633.954

   FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  119.295) + 0.65*(  101.901) =   107.989  PPM
                                               CO    0.35*(     .079) + 0.65*(     .072) =      .074  PERCENT
                                               NO    0.35*(  602.381) + 0.65*(  633.954) =   622.904  PPM
                                                                          CORRECTED NO =   654.510  PPM

   DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
        8-2-72  RUN3  2-3 4RTDC 600RPM W/AIR EGR OXIDATION CATALYST        K =1.051      HUM =  90  GR/LB
        ----------------------------------------------------------------------------------------------------------------
        FEDERAL      CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D    WEIGHTING         W E I G H T E D
        MODE           HC     CO     CO2     NO     FACTOR      HC     CO     NO     FACTOR        HC       CO        NO
        ----------------------------------------------------------------------------------------------------------------
CYCLE 1
        1 IDLE         32   .020   8.930     51     1.616       52   .032     82      .036       1.861     .001     2.966
        2 16'HG       253   .020   8.750     83     1.605      406   .032    133      .089      36.144     .003    11.857
        3 10'HG        22   .020  10.550    164     1.370       30   .027    232      .257       7.746     .007    59.504
        4 16'HG        88   .020   8.930     77     1.605      141   .032    124      .089      12.569     .003    10.998
        5 19'HG       693   .020   7.000     64     1.869     1295   .037    120      .047      60.873     .002     5.622
        6 16'HG       106   .020   8.930     58     1.601      170   .032     93      .089      15.108     .003     8.267
        7  3'HG        17   .070  13.060   1546     1.106       19   .077   1709      .283       5.320     .022   483.782
        8 16'HG        21   .020   9.250    112     1.562       33   .031    175      .089       2.919     .003    15.571
        9 C.T.        364   .040   4.600     64     2.892     1053   .116    185      .021      22.110     .002     3.807
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    164.650     .046   602.455
CYCLE 2
        1 IDLE         32   .020   8.930     51     1.616       52   .032     82      .036       1.861     .001     2.966
        2 16'HG       216   .020   8.750     64     1.612      348   .032    103      .089      30.995     .003     9.184
        3 10'HG        17   .020  10.780    183     1.342       23   .027    246      .257       5.861     .007    63.095
        4 16'HG        44   .020   9.250     96     1.558       69   .031    150      .089       6.101     .003    13.311
        5 19'HG       694   .020   7.090     64     1.847     1282   .037    118      .047      60.253     .002     5.557
        6 16'HG       102   .020   8.930     70     1.602      163   .032    112      .089      14.545     .003     9.982
        7  3'HG        17   .070  13.330   1518     1.083       18   .076   1645      .283       5.212     .021   465.437
        8 16'HG        17   .020   9.370    122     1.543       26   .031    188      .089       2.334     .003    16.752
        9 C.T.        333   .040   4.750     68     2.827      941   .113    192      .021      19.767     .002     4.037
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    146.930     .045   590.319
CYCLE 3
        1 IDLE          8   .020   9.370     77     1.544       12   .031    119      .036        .445     .001     4.281
        2 16'HG       131   .020   8.930     97     1.597      209   .032    155      .089      18.615     .003    13.784
        3 10'HG        13   .050  10.550    189     1.369       18   .068    259      .257       4.575     .018    66.513
        4 16'HG        61   .020   8.930     97     1.610       98   .032    156      .089       8.741     .003    13.900
        5 19'HG       688   .050   6.820     77     1.911     1315   .096    147      .047      61.791     .004     6.916
        6 16'HG        87   .050   8.930     77     1.602      139   .080    123      .089      12.407     .007    10.981
        7  3'HG        17   .070  13.330   1552     1.083       18   .076   1681      .283       5.212     .021   475.862
        8 16'HG        17   .050   9.370    117     1.540       26   .077    180      .089       2.331     .007    16.040
        9 C.T.        341   .040   4.750     79     2.822      962   .113    223      .021      20.208     .002     4.682
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    134.325     .067   612.958
CYCLE 4
        1 IDLE          8   .020   9.370     77     1.544       12   .031    119      .036        .445     .001     4.281
        2 16'HG       188   .020   8.840     97     1.602      301   .032    155      .089      26.799     .003    13.827
        3 10'HG        13   .020  10.780    199     1.342       17   .027    267      .257       4.484     .007    68.639
        4 16'HG        66   .020   9.030    103     1.591      105   .032    164      .089       9.348     .003    14.589
        5 19'HG       666   .020   7.000     77     1.876     1249   .038    144      .047      58.722     .002     6.789
        6 16'HG        71   .020   9.140     77     1.572      112   .031    121      .089       9.930     .003    10.770
        7  3'HG        13   .070  13.180   1540     1.096       14   .077   1688      .283       4.032     .022   477.691
        8 16'HG        13   .020   9.370    130     1.544       20   .031    201      .089       1.786     .003    17.859
        9 C.T.        337   .040   4.720     80     2.841      957   .114    227      .021      20.105     .002     4.773
        SUM-----------(CYCLE COMPOSITE)---------------------------------------------------    135.652     .045   619.217

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------    155.790     .045   596.387

        AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------    134.989     .056   616.087

        FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  155.790) + 0.65*(  134.989) =   142.269  PPM
                                                    CO    0.35*(     .045) + 0.65*(     .056) =      .052  PERCENT
                                                    NO    0.35*(  596.387) + 0.65*(  616.087) =   609.192  PPM
                                                                                CORRECTED NO =   640.103  PPM

        DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
     8-2-72  RUN1  2-3 4BTDC 600RPM W/AIR EGR OXIDATION CATALYST       K = 1.04     HUM =  90  GR/LB
---------------------------------------------------------------------------------------------------------------
     MASS         CONCENTRATION AS MEASURED        TOTAL    FUEL     ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
     MODE           HC     CO     CO2      NO     CARBON    CONS.      HC     CO    NO2    FACT.    HC       CO   NO2(K)  HP
---------------------------------------------------------------------------------------------------------------
CYCLE 1
     1 IDLE         65   .220    9.41      52     9.700     1634      12     75      3    .232     2.7      17     .7    0
     2 16 HG       521   .340    8.21      77     9.113     5534     342    417     16    .077    26.3      32    1.2    7
     3 10 HG        35   .180   10.95     146    11.168     9897      33    322     43    .147     4.9      47    6.3   30
     4 16 HG        76   .080    9.06     103     9.222     5539      49     97     21    .077     3.8       7    1.6    7
     5 19 HG       612   .070    7.18      64     7.911     3178     266     57      9    .057    15.1       3     .5    9
     6 16 HG        60   .100    9.21      77     9.375     5539      38    119     15    .077     2.9       9    1.2    7
     7  3 HG        21   .140   13.20    1482    13.363    18560      32    393    683    .113     3.6      44   77.2   81
     8 16 HG        21   .100    9.37     103     9.493     5539      13    118     20    .077     1.0       9    1.5    7
     9 C.T.        320   .110    4.73      64     5.186      994      66     43      4    .143     9.5       6     .6    0
     SUM-----------(CYCLE COMPOSITE)---------------------------------------------------     4.3      11    5.6
CYCLE 2
     1 IDLE         65   .220    9.41      52     9.700     1634      12     75      3    .232     2.7      17     .7    0
     2 16 HG       176   .080    8.78      90     9.050     5539     116     99     18    .077     9.0       8    1.4    7
     3 10 HG        13   .100   10.78     210    10.894     9897      13    184     63    .147     1.9      27    9.3   30
     4 16 HG        48   .100    9.14     100     9.292     5539      31    120     20    .077     2.4       9    1.5    7
     5 19 HG       642   .070    7.23      64     7.993     3178     276     56      8    .057    15.7       3     .5    9
     6 16 HG        66   .090    9.25      77     9.411     5539      42    107     15    .077     3.2       8    1.2    7
     7  3 HG        13   .130   13.33    1463    13.474    18560      14    362    669    .113     2.2      41   75.6   81
     8 16 HG        17   .070    9.37     103     9.458     5539      11     83     20    .077      .8       6    1.5    7
     9 C.T.        318   .110    4.69      73     5.143      994      66     43      5    .143     9.5       6     .7    0
     SUM-----------(CYCLE COMPOSITE)---------------------------------------------------     2.9       8    5.7
CYCLE 3
     1 IDLE          8   .070    9.25      77     9.329     1634       2     25      4    .232      .4       6    1.0    0
     2 16 HG       138   .070    8.93      74     9.149     5539      90     86     15    .077     6.9       7    1.1    7
     3 10 HG         8   .100   10.78     224    10.889     9897       8    184     68    .147     1.2      27    9.9   30
     4 16 HG        57   .070    9.03     103     9.162     5539      37     85     21    .077     2.9       7    1.6    7
     5 19 HG       715   .090    7.00      64     7.862     3178     312     73      9    .057    17.8       4     .5    9
     6 16 HG        70   .090    9.18      77     9.346     5539      45    108     15    .077     3.5       8    1.2    7
     7  3 HG        17   .130   13.18    1510    13.328    18560      26    366    698    .113     2.9      41   78.9   81
     8 16 HG        16   .070    9.19     109     9.277     5539      10     84     22    .077      .8       7    1.7    7
     9 C.T.        317   .100    4.39      72     4.832      994      70     42      5    .143    10.1       6     .7    0
     SUM-----------(CYCLE COMPOSITE)---------------------------------------------------     2.9       7    6.0
CYCLE 4
     1 IDLE          8   .070    9.25      77     9.329     1634       2     25      4    .232      .4       6    1.0    0
     2 16 HG       103   .070    9.14     103     9.321     5539      66     84     20    .077     5.1       6    1.6    7
     3 10 HG         8   .070   10.78     237    10.854     9897       8    129     72    .147     1.2      19   10.5   30
     4 16 HG        50   .070    9.14     103     9.264     5539      32     85     20    .077     2.5       7    1.6    7
     5 19 HG       671   .070    7.09      77     7.885     3178     292     57     10    .057    16.6       3     .6    9
     6 16 HG        73   .070    9.14      77     9.289     5539      47     84     15    .077     3.6       6    1.2    7
     7  3 HG        13   .110   13.18    1463    13.304    18560      20    310    678    .113     2.2      35   76.6   81
     8 16 HG        13   .070    9.19     117     9.274     5539       8     84     23    .077      .6       7    1.8    7
     9 C.T.        325   .090    4.61      73     5.051      994      69     36      5    .143     9.9       5     .7    0
     SUM-----------(CYCLE COMPOSITE)---------------------------------------------------     2.6       6    5.9

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------     3.6       9    5.7

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------     2.7       6    5.9

     FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.6) + 0.65(     2.7) =    3.048  (MASS)
                                              CO  0.35(       9) + 0.65(       6) =      7.4  (MASS)
                                              NO2 0.35(     5.7) + 0.65(     5.9) =    5.848  (MASS)
                                                                 CORRECTED NO2 =    6.098  (MASS)
```

```
    8-2-72  RUN-2 2-3 4BTOC 600 RPM W/AIR EGR  OXIDATION CATALYST      K = 1.04      HUM =  90  GR/LB
    ---------------------------------------------------------------------------------------------------------------
    MASS       CONCENTRATION AS MEASURED         TOTAL    FUEL        ADJUSTED (MASS)       WT.      WEIGHTED (MASS)
    MODE         HC     CO     CO2      NO      CARBON   CONS.      HC      CO     NO2     FACT.     HC     CO  NO2(K)  HP
    ---------------------------------------------------------------------------------------------------------------
CYCLE 1
    1 IDLE       21   .050    8.75      64     8.823    1634         4      19       4    .232     1.0      4     .9    0
    2 16 HG     239   .050    8.60      64     8.908    5539       160      63      13    .077    12.4      5    1.0    7
    3 10 HG      13   .050   10.43     157    10.494    9897        13      95      49    .147     1.9     14    7.2   30
    4 16 HG      49   .050    8.84      90     8.943    5539        33      63      19    .077     2.5      5    1.4    7
    5 19 HG     573   .050    7.00      57     7.669    3178       256      42       8    .057    14.6      2     .4    9
    6 16 HG      63   .050    8.84      64     8.958    5539        42      62      13    .077     3.2      5    1.0    7
    7  3 HG       4   .070   13.06    1463    13.134   18560         6     200     686    .113      .7     23   77.6   81
    8 16 HG       4   .050    9.14     112     9.194    5539         3      61      22    .077      .2      5    1.7    7
    9 C.T.      243   .060    4.93      63     5.306     994        59      23       4    .143     8.5      3     .6    0
    SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------------     2.8      4    5.7
CYCLE 2
    1 IDLE       21   .050    8.75      64     8.823    1634         4      19       4    .232     1.0      4     .9    0
    2 16 HG     113   .050    8.84      90     9.012    5539        75      62      18    .077     5.8      5    1.4    7
    3 10 HG       4   .050   10.66     210    10.714    9897         4      93      64    .147      .6     14    9.5   30
    4 16 HG      48   .050    8.93      96     9.032    5539        32      62      20    .077     2.4      5    1.5    7
    5 19 HG     625   .050    6.82      64     7.545    3178       284      43       9    .057    16.2      2     .5    9
    6 16 HG      62   .050    8.93      64     9.047    5539        41      62      13    .077     3.2      5    1.0    7
    7  3 HG       4   .070   12.94    1559    13.014   18560         6     202     738    .113      .7     23   83.4   81
    8 16 HG       9   .050    9.14     108     9.200    5539         6      61      22    .077      .5      5    1.7    7
    9 C.T.      295   .050    4.59      65     4.959     994        64      20       4    .143     9.1      3     .6    0
    SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------------     2.4      4    6.2
CYCLE 3
    1 IDLE        4   .020    8.84      70     8.864    1634         1       7       4    .232      .2      2    1.0    0
    2 16 HG     111   .020    8.84      90     8.980    5539        74      25      18    .077     5.7      2    1.4    7
    3 10 HG       4   .050   10.51     190    10.564    9897         4      95      59    .147      .6     14    8.7   30
    4 16 HG      37   .050    8.93      97     9.020    5539        25      62      20    .077     1.9      5    1.5    7
    5 19 HG     590   .050    7.09      71     7.777    3178       260      41      10    .057    14.8      2     .5    9
    6 16 HG      50   .050    9.03      77     9.134    5539        33      61      16    .077     2.5      5    1.2    7
    7  3 HG       4   .070   13.06    1579    13.134   18560         6     200     741    .113      .7     23   83.7   81
    8 16 HG       6   .020    9.18     108     9.206    5539         4      24      22    .077      .3      2    1.7    7
    9 C.T.      296   .060    4.58      66     4.960     994        64      24       4    .143     9.2      3     .6    0
    SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------------     2.2      4    6.2
CYCLE 4
    1 IDLE        4   .050    8.84      70     8.894    1634         1      19       4    .232      .2      4    1.0    0
    2 16 HG      88   .050    8.84      90     8.985    5539        59      62      18    .077     4.5      5    1.4    7
    3 10 HG       4   .050   10.55     197    10.604    9897         4      94      61    .147      .6     14    9.0   30
    4 16 HG      40   .050    8.84     103     8.933    5539        27      63      21    .077     2.1      5    1.6    7
    5 19 HG     588   .050    6.91      71     7.595    3178       266      42      10    .057    15.1      2     .6    9
    6 16 HG      51   .020    8.93      77     9.005    5539        34      25      16    .077     2.6      2    1.2    7
    7  3 HG       4   .070   12.94    1579    13.014   18560         6     202     748    .113      .7     23   84.5   81
    8 16 HG       9   .050    9.14     117     9.200    5539         6      61      23    .077      .5      5    1.8    7
    9 C.T.      301   .060    4.56      68     4.945     994        65      24       5    .143     9.3      3     .6    0
    SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------------     2.2      4    6.3

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------------     2.6      4    6.0

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------------     2.2      4    6.3

    FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.6) + 0.65(     2.2) =    2.352  (MASS)
                                             CO  0.35(       4) + 0.65(       4) =      3.8  (MASS)
                                             NO2 0.35(     6.0) + 0.65(     6.3) =    6.147  (MASS)
                                                              CORRECTED NO2 =    6.410  (MASS)
```

```
   8-2-72  RUN3  2-3 4BTDC 600RPM W/AIR EGR OXIDATION CATALYST        K = 1.04     HUM =  90  GR/LB
   ------------------------------------------------------------------------------------------------------------------
   MASS          CONCENTRATION AS MEASURED      TOTAL    FUEL       ADJUSTED (MASS)        WT.       WEIGHTED (MASS)
   MODE           HC      CO      CO2     NO    CARBON   CONS.      HC      CO    NO2    FACT.     HC        CO   NO2(K)  HP
   ------------------------------------------------------------------------------------------------------------------

CYCLE 1
   1 IDLE         42    .020    8.93     51    8.985    1634        6       7      3    .232      1.5        2     .7     0
   2 16 HG       253    .020    8.75     83    9.043    5539      167      25     17    .077     12.9        2    1.3     7
   3 10 HG        22    .020   10.55    164   10.594    4897       22      38     52    .147      3.3        6    7.7    30
   4 16 HG        88    .020    8.93     77    9.045    5539       58      25     16    .077      4.5        2    1.2     7
   5 19 HG       693    .020    7.00     64    7.768    3178      306      17      9    .057     17.5        1     .5     9
   6 16 HG       106    .020    8.93     58    9.064    5539       70      25     12    .077      5.4        2     .9     7
   7  3 HG        17    .070   13.06   1546   13.148   18560       26     200    725    .113      2.9       23   81.9    81
   8 16 HG        21    .020    9.25    112    9.293    5539       14      24     22    .077      1.0        2    1.7     7
   9 C.T.        364    .040    4.60     64    5.033     994       78      16      4    .143     11.1        2     .6     0
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------------   3.7        3    6.0

CYCLE 2
   1 IDLE         32    .020    8.93     51    8.985    1634        6       7      3    .232      1.5        2     .7     0
   2 16 HG       216    .020    8.75     64    9.003    5539      144      25     13    .077     11.1        2    1.0     7
   3 10 HG        17    .020   10.78    183   10.818    9897       17      37     56    .147      2.5        5    8.2    30
   4 16 HG        44    .020    9.25     96    9.318    5539       28      24     19    .077      2.2        2    1.5     7
   5 19 HG       694    .020    7.09     64    7.860    3178      303      16      9    .057     17.3        1     .5     9
   6 16 HG       102    .020    8.93     70    9.060    5539       67      25     14    .077      5.2        2    1.1     7
   7  3 HG        17    .070   13.33   1518   13.418   18560       25     196    697    .113      2.9       22   78.8    81
   8 16 HG        17    .020    9.37    122    9.408    5539       11      24     24    .077       .8        2    1.8     7
   9 C.T.        333    .040    4.75     68    5.150     994       69      16      4    .143      9.9        2     .6     0
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------------   3.3        2    5.8

CYCLE 3
   1 IDLE          8    .020    9.37     77    9.399    1634        2       7      4    .232       .3        2    1.0     0
   2 16 HG       131    .020    8.93     97    9.091    5539       86      25     20    .077      6.6        2    1.5     7
   3 10 HG        13    .050   10.55    189   10.614    9897       13      94     59    .147      1.9       14    8.6    30
   4 16 HG        61    .020    8.93     97    9.016    5539       40      25     20    .077      3.1        2    1.5     7
   5 19 HG       688    .050    6.82     77    7.613    3178      310      42     11    .057     17.7        2     .6     9
   6 16 HG        87    .050    8.93     77    9.074    5539       57      62     16    .077      4.4        5    1.2     7
   7  3 HG        17    .070   13.33   1552   13.418   18560       25     196    713    .113      2.9       22   80.5    81
   8 16 HG        17    .050    9.37    117    9.438    5539       11      59     23    .077       .8        5    1.8     7
   9 C.T.        341    .040    4.75     79    5.158     994       71      16      5    .143     10.1        2     .7     0
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------------   3.0        3    6.0

CYCLE 4
   1 IDLE          8    .020    9.37     77    9.399    1634        2       7      4    .232       .3        2    1.0     0
   2 16 HG       188    .020    8.84     97    9.063    5539      124      25     20    .077      9.6        2    1.5     7
   3 10 HG        13    .020   10.78    199   10.814    9897       13      37     60    .147      1.9        5    8.9    30
   4 16 HG        66    .020    9.03    103    9.121    5539       43      25     21    .077      3.3        2    1.6     7
   5 19 HG       666    .020    7.00     77    7.739    3178      295      17     10    .057     16.8        1     .6     9
   6 16 HG        71    .020    9.14     77    9.237    5539       46      24     15    .077      3.5        2    1.2     7
   7  3 HG        13    .070   13.18   1540   13.264   18560       20     198    715    .113      2.2       22   80.8    81
   8 16 HG        13    .020    9.37    130    9.404    5539        8      24     25    .077       .6        2    2.0     7
   9 C.T.        337    .040    4.72     80    5.124     994       71      16      5    .143     10.1        2     .7     0
   SUM------------(CYCLE COMPOSITE)-------------------------------------------------------------   3.0        2    6.1

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------------   3.5        2    5.9

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------------   3.0        3    6.1

   FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.5) + 0.65(     3.0) =    3.165  (MASS)
                                            CO  0.35(       2) + 0.65(       3) =      2.8  (MASS)
                                            NO2 0.35(     5.9) + 0.65(     6.1) =    6.003  (MASS)
                                                              CORRECTED NO2 =    6.260  (MASS)
```

APPENDIX P

ENGINE 2-3

STANDARD 1972 ENGINE EMISSION RATES

TABULAR DATA

EXPERIMENTAL 23 MODE MASS

NINE-MODE FTP CONCENTRATION

NINE-MODE CALIFORNIA ARB MASS

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-3-72  RUN-1     ENG.2-3   1972 VERSION  4 BTDC STAT.ERL
-------------------------------------------------------------------------------
               DYNA.        MAN. FUEL    A/F            DRY CONCENTRATION
MODE SPEED     LOAD     HP  VAC. LB/HR  RATIO    ALDE.     HC      CO       CO2     NO
-------------------------------------------------------------------------------
   1   600      0.0      0  18.2   3.5   14.9        0   6523   2.780    12.82     40
   2  1200      5.0      1  19.4   7.5   15.5        0    834    .470    14.05    104
   3  1200     19.0      4  19.0   7.5   15.6        0    758    .280    13.91    131
   4  1200     42.0     10  17.9   8.1   16.2        0   1407    .130    13.48    370
   5  1200     58.0     13  16.4   8.3   16.3        0   1507    .150    13.33    720
   6  1200    116.0     27  10.7  14.5   16.7        0   1300    .100    12.94   1212
   7  1200    175.0     40   5.7  20.2   15.3        0   1518    .280    14.05   1975
   8  1200    191.0     44   3.8  21.8   15.5        0   1368    .250    13.91   2100
   9  1200    214.0     49   2.3  23.0   15.5        0   1324    .150    14.05   2350
  10  1200    233.0     53    .3  30.6   13.1        0   2566   4.840    11.72   1087
  11   600      0.0      0  18.3   3.3   14.5        0   3864   1.800    12.94     51
  12  1200      0.0      0  22.0   3.6   16.3        0  54458    .470     6.54      7
  13  2300    250.0    109    .6  64.5   12.4        0   2690   6.310    10.66    913
  14  2300    230.0    101   2.7  48.5   14.6        0   1299   1.450    13.63   1950
  15  2300    205.0     90   4.8  44.8   14.4        0   1290   1.630    13.63   1837
  16  2300    186.0     81   6.3  41.7   14.3        0   1586   1.730    13.48   1762
  17  2300    125.0     55  11.1  28.4   15.9        0    587    .150    13.77   2050
  18  2300     63.0     28  16.3  18.4   16.1        0    541    .150    13.48   1375
  19  2300     45.0     20  18.0  16.3   16.2        0    400    .150    13.48    738
  20  2300     20.0      9  19.8  13.5   16.4        0    236    .130    13.48    310
  21  2300      5.0      2  20.6  11.7   16.4        0    190    .130    13.33    140
  22   600      0.0      0  18.3   3.5   14.9        0   3809   1.630    13.18     49
  23  2300      0.0      0  24.9   3.8   19.8        0  38328    .360     8.05      8
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------
   1   0.0    67.7     549     1.3  .070      0.0      I       R        R       R
   2   0.0    19.4     221     8.0  .060       .1    0.0   17.00    193.6     7.0
   3   0.0    16.1     135    10.4  .060       .3    0.0    4.16     31.1     2.4
   4   0.0    37.6      70    32.8  .050       .5    0.0    3.92      7.3     3.4
   5   0.0    41.6      84    66.0  .030       .4    0.0    3.14      6.3     5.0
   6   0.0    64.4     101   201.0  .060      1.6    0.0    2.45      3.8     7.6
   7   0.0    46.0     358   414.9 0.000      0.0    0.0    2.40      8.9    10.4
   8   0.0    44.7     349   482.2  .040      1.7    0.0    2.17      8.0    11.0
   9   0.0    46.4     221   567.9 0.000      0.0    0.0    1.97      4.5    11.6
  10   0.0   211.8    8070   297.9 0.000      0.0    0.0    3.98    151.6     5.6
  11   0.0    38.2     360     1.7  .070      0.0      I       R        R       R
  12   0.0   717.6     124      .3  .120      0.0      I       R        R       R
  13   0.0   456.5   21632   514.2  .025      2.7    0.0    4.17    197.6     4.7
  14   0.0   187.9    4237   936.4  .055      5.5    0.0    1.87     42.1     9.3
  15   0.0   170.3    4348   805.4  .035      3.1    0.0    1.90     48.4     9.0
  16   0.0   145.1    4301   720.2  .060      4.9    0.0    2.40     52.8     8.8
  17   0.0    54.1     279   627.2  .060      3.3    0.0     .99      5.1    11.5
  18   0.0    33.0     185   278.4 0.000      0.0    0.0    1.19      6.7    10.1
  19   0.0    21.6     164   132.4  .065      1.3    0.0    1.10      8.3     6.7
  20   0.0    10.6     118    46.2 0.000      0.0    0.0    1.21     13.5     5.3
  21   0.0     7.5     103    24.8 0.000      0.0    0.0    3.41     47.2    11.3
  22   0.0    39.8     344     1.7  .080      0.0      I       R        R       R
  23   0.0   539.6     102      .4  .060      0.0      I       R        R       R

CYCLE COMPOSITE     HC      7.316    GRAM/BHP HR
                    CO     53.947    GRAM/BHP HR
                    NO2     8.597    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .623      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
 8-3-72  RUN-2         ENG.2-3    1972 VERSION  4 BTDC STAT.ERL
--------------------------------------------------------------------------------
                DYNA.          MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED      LOAD     HP    VAC. LB/HR   RATIO    ALDE.      HC       CO       CO2      NO
--------------------------------------------------------------------------------
  1    600       0.0      0    18.2   3.5    15.1        0    5200    1.380    12.71      41
  2   1200       5.0      1    19.5   7.6    15.5        0     702     .390    13.91     104
  3   1200      19.0      4    19.0   7.7    15.5        0     928     .280    13.91     151
  4   1200      42.0     10    17.9   8.0    16.1        0    1396     .100    13.48     370
  5   1200      58.0     13    16.5   8.4    16.3        0    1572     .100    13.18     680
  6   1200     116.0     27    10.8  14.3    16.7        0    1378     .100    12.94    1313
  7   1200     175.0     40     5.7  20.1    15.2        0    1587     .280    14.18    2050
  8   1200     191.0     44     3.8  21.7    15.6        0    1413     .210    13.91    2200
  9   1200     214.0     49     2.3  23.0    15.5        0    1469     .150    13.91    2350
 10   1200     233.0     53      .3  30.7    13.1        0    2708    4.880    11.60    1037
 11    600       0.0      0    18.5   3.7    14.1        0    3998    2.440    12.94      53
 12   1200       0.0      0    22.0   3.6    16.2        0   55004     .470     6.55       6
 13   2300     250.0    109      .6  64.5    12.4        0    2892    6.310    10.66     900
 14   2300     230.0    101     2.7  48.2    14.7        0    1267    1.230    13.77    2100
 15   2300     205.0     90     4.8  44.5    14.6        0    1265    1.480    13.63    1987
 16   2300     186.0     81     6.3  41.4    14.5        0    1471    1.380    13.77    2200
 17   2300     125.0     55    11.0  28.5    16.1        0     555     .150    13.48    2150
 18   2300      63.0     28    16.4  18.5    16.3        0     475     .150    13.33    1313
 19   2300      45.0     20    18.0  16.3    16.4        0     343     .130    13.33     795
 20   2300      20.0      9    19.8  13.4    16.5        0     222     .100    13.33     330
 21   2300       5.0      2    20.6  11.9    16.5        0     188     .100    13.18     200
 22    600       0.0      0    18.3   3.5    15.5        0    3959     .850    13.33      47
 23   2300       0.0      0    24.9   3.8    19.9        0   38129     .360     8.10       8
--------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.      HP   ALDE.     HC       CO      NO2
--------------------------------------------------------------------------------
  1    0.0    56.5     303     1.5   .070     0.0      I       R        R        R
  2    0.0    16.8     189     8.3   .060      .1    0.0   14.74    165.4      7.2
  3    0.0    22.7     138    12.3   .060      .3    0.0    5.23     31.9      2.8
  4    0.0    36.9      53    32.5   .050      .5    0.0    3.85      5.6      3.4
  5    0.0    44.6      57    64.0   .030      .4    0.0    3.36      4.3      4.8
  6    0.0    67.8      99   214.5   .060     1.6    0.0    2.56      3.8      8.1
  7    0.0    99.0     353   424.5  0.000     0.0    0.0    2.48      8.8     10.6
  8    0.0    47.5     293   504.1   .040     1.7    0.0    2.24      6.7     11.6
  9    0.0   117.9     223   572.9  0.000     0.0    0.0    2.21      4.6     11.7
 10    0.0   225.1    8195   286.4  0.000     0.0    0.0    4.23    153.9      5.4
 11    0.0    42.5     524     1.9   .070     0.0      I       R        R        R
 12    0.0   717.4     124      .3   .120     0.0      I       R        R        R
 13    0.0   440.3   21607   506.5   .025     2.7    0.0    4.48    197.4      4.6
 14    0.0   183.1    3591  1007.7   .055     5.5    0.0    1.82     35.7     10.0
 15    0.0   167.6    3961   874.2   .035     3.1    0.0    1.87     44.1      9.7
 16    0.0   180.6    3422   896.7   .060     4.9    0.0    2.22     42.0     11.0
 17    0.0    52.4     286   674.3   .060     3.3    0.0     .96      5.2     12.3
 18    0.0    29.5     188   270.3  0.000     0.0    0.0    1.07      6.8      9.8
 19    0.0    18.8     144   144.6   .065     1.3    0.0     .95      7.3      7.3
 20    0.0    10.0      91    49.5  0.000     0.0    0.0    1.15     10.4      5.7
 21    0.0     7.6      82    27.0  0.000     0.0    0.0    3.49     37.4     12.3
 22    0.0    43.1     187     1.7   .080     0.0      I       R        R        R
 23    0.0   435.5     102      .4   .060     0.0      I       R        R        R

CYCLE COMPOSITE      HC      7.300    GRAM/BHP HR
                     CO     48.938    GRAM/BHP HR
                     NO2     9.466    GRAM/BHP HR
                     ALDE    0.000    GRAM/BHP HR
                     BSFC     .622      LB/BHP HR
```

```
6-4-72   RUN 1 2-3 4BTDC 600RPM  E.R.L STD.ENG.   STA.                K =1.031     HUM =  84  GR/LB
------------------------------------------------------------------------------------------------------
FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING      W E I G H T E D
MODE           HC      CO     CO2     NO     FACTOR     HC      CO    NO    FACTOR       HC      CO       NO
------------------------------------------------------------------------------------------------------
CYCLE 1
       1 IDLE         149   .800  13.480    105    1.033      153    .826   108     .036       5.503   .030     3.904
       2 16'HG         93   .180  13.770   1135    1.039       97    .187  1179     .089       8.597   .017   104.919
       3 10'HG         49   .180  13.770   1377    1.042       51    .188  1435     .257      13.124   .048   368.822
       4 16'HG         40   .180  13.770    956    1.043       42    .188   997     .089       3.713   .017    88.736
       5 19'HG         26   .180  13.770    393    1.044       27    .188   410     .047       1.276   .009    19.285
       6 16'HG         40   .180  13.630   1085    1.054       42    .190  1143     .089       3.751   .017   101.735
       7  3'HG         75  1.110  14.310   1939     .970       73   1.077  1881     .283      20.592   .305   532.362
       8 16'HG         35   .180  14.420   1371     .997       35    .179  1366     .089       3.105   .016   121.618
       9 C.T.        1712   .950   8.130    129    1.387     2375   1.318   179     .021      49.867   .028     3.757
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     109.526   .485  1345.138
CYCLE 2
       1 IDLE         148   .800  13.480    105    1.033      153    .826   108     .036       5.503   .030     3.904
       2 16'HG         76   .180  13.770   1036    1.040       79    .187  1077     .089       7.035   .017    95.894
       3 10'HG         49   .180  13.910   1599    1.032       51    .186  1650     .257      12.994   .048   424.017
       4 16'HG         44   .180  13.910   1185    1.032       45    .186  1223     .089       4.042   .017   108.862
       5 19'HG         26   .180  13.910    501    1.034       27    .186   518     .047       1.263   .009    24.339
       6 16'HG         40   .180  13.770   1236    1.043       42    .188  1289     .089       3.713   .017   114.726
       7  3'HG         76  1.160  14.310   1939     .968       74   1.123  1878     .283      20.830   .318   531.435
       8 16'HG         35   .180  14.050   1431    1.023       36    .184  1464     .089       3.186   .016   130.253
       9 C.T.        1661   .980   8.940    147    1.292     2146   1.266   190     .021      45.062   .027     3.988
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     103.627   .497  1437.418
CYCLE 3
       1 IDLE          89  1.170  14.180    165     .976       87   1.142   161     .036       3.126   .041     5.796
       2 16'HG         80   .180  13.910   1195    1.029       82    .185  1220     .089       7.329   .016   108.562
       3 10'HG         48   .180  14.050   1676    1.022       49    .184  1712     .257      12.604   .047   440.085
       4 16'HG         44   .180  14.050   1224    1.022       45    .184  1251     .089       4.002   .016   111.335
       5 19'HG         31   .180  14.050    542    1.023       32    .184   554     .047       1.491   .009    26.061
       6 16'HG         44   .180  14.050   1306    1.022       45    .184  1335     .089       4.002   .016   118.794
       7  3'HG         80  1.200  14.310   1939     .967       77   1.160  1875     .283      21.891   .328   530.573
       8 16'HG         35   .210  14.050   1389    1.022       36    .215  1419     .089       3.182   .019   126.297
       9 C.T.        1624   .900   9.100    168    1.283     2083   1.154   216     .021      43.747   .024     4.526
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------     101.374   .518  1472.028
CYCLE 4
       1 IDLE          89  1.170  14.180    165     .976       87   1.142   161     .036       3.126   .041     5.796
       2 16'HG         71   .180  13.910   1195    1.030       73    .185  1231     .089       6.509   .017   109.553
       3 10'HG         48   .180  14.050   1702    1.022       49    .184  1739     .257      12.604   .047   446.912
       4 16'HG         44   .180  13.960   1202    1.029       45    .185  1236     .089       4.028   .016   110.032
       5 19'HG         31   .180  14.050    501    1.023       32    .184   513     .047       1.491   .009    24.089
       6 16'HG         44   .190  14.050   1305    1.022       45    .184  1335     .089       4.002   .016   118.794
       7  3'HG         77  1.200  14.420   1982     .960       74   1.152  1903     .283      20.921   .326   538.506
       8 16'HG         25   .190  14.050   1468    1.023       26    .194  1502     .089       2.276   .017   133.676
       9 C.T.        1603   .850   9.070    127    1.292     2070   1.098   164     .021      43.480   .023     3.445
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      98.437   .513  1490.803

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------     106.577   .491  1391.278

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------      99.905   .515  1481.415

       FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  106.577) + 0.65*(   99.905) =   102.240  PPM
                                                   CO    0.35*(     .491) + 0.65*(     .515) =      .507  PERCENT
                                                   NO    0.35*( 1391.278) + 0.65*( 1481.415) =  1449.867  PPM
                                                                               CORRECTED NO =  1495.356  PPM

       DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
8-4-72   RUN 2 2-3 4BTDC 5100RPM  E.R.L STD.ENG.   STA.                K =1.031     HUM =  84  GR/LB
--------------------------------------------------------------------------------------------------------------
FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING        W E I G H T E D
MODE             HC     CO     CO2     NO     FACTOR      HC     CO    NO     FACTOR         HC      CO        NO
--------------------------------------------------------------------------------------------------------------
CYCLE 1
  1 IDLE        427   .810  12.220     90     1.108      473   .898   100    .036         17.033   .032     3.590
  2 16'HG       120   .180  12.040   1444     1.178      141   .212  1701    .089         12.580   .019   151.384
  3 10'HG        62   .180  13.060   1463     1.097       68   .197  1605    .257         17.481   .051   412.490
  4 16'HG        49   .180  12.940   1031     1.108       54   .199  1143    .089          4.833   .018   101.698
  5 19'HG        36   .180  12.340    450     1.163       42   .209   523    .047          1.968   .010    24.595
  6 16'HG        44   .180  12.920   1117     1.110       49   .200  1240    .089          4.349   .018   110.395
  7  3'HG        80  1.090  13.630   2040     1.017       81  1.108  2074    .283         23.019   .314   586.979
  8 16'HG        42   .210  13.180   1520     1.089       46   .228  1653    .089          4.066   .020   147.150
  9 C.T.       2444  1.100   6.560    133     1.487     3635  1.636   198    .021         76.332   .034     4.154
  SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      161.660   .516  1542.436
CYCLE 2
  1 IDLE        427   .810  12.220     90     1.108      473   .898   100    .036         17.033   .032     3.590
  2 16'HG        79   .180  13.060   1170     1.096       87   .197  1282    .089          7.703   .018   114.080
  3 10'HG        49   .180  13.180   1625     1.088       53   .196  1769    .257         13.706   .050   454.522
  4 16'HG        45   .180  13.180   1313     1.089       49   .196  1429    .089          4.360   .017   127.223
  5 19'HG        31   .180  13.330    582     1.078       33   .194   627    .047          1.570   .009    29.482
  6 16'HG        45   .180  13.180   1292     1.089       49   .196  1407    .089          4.360   .017   125.188
  7  3'HG        76  1.300  13.630   2130     1.010       77  1.312  2150    .283         21.715   .371   608.579
  8 16'HG        40   .180  13.330   1625     1.077       43   .194  1750    .089          3.834   .017   155.763
  9 C.T.       2372  1.090   6.750    152     1.471     3489  1.603   224    .021         73.277   .034     4.696
  SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      147.558   .567  1623.121
CYCLE 3
  1 IDLE        156  1.010  13.480    130     1.024      160  1.035   133    .036          5.753   .037     4.795
  2 16'HG        70   .180  13.850   1295     1.035       72   .186  1340    .089          6.445   .017   119.238
  3 10'HG        45   .180  13.940   1759     1.030       46   .185  1812    .257         11.911   .048   465.594
  4 16'HG        45   .180  13.940   1392     1.030       46   .185  1434    .089          4.125   .016   127.596
  5 19'HG        31   .180  14.030    620     1.024       32   .184   635    .047          1.493   .009    29.853
  6 16'HG        37   .180  13.980   1539     1.028       38   .185  1582    .089          3.384   .016   140.757
  7  3'HG        76  1.200  13.630   2143     1.013       77  1.216  2171    .283         21.790   .344   614.432
  8 16'HG        36   .180  13.940   1598     1.031       37   .186  1647    .089          3.302   .017   146.580
  9 C.T.       2318  1.150   6.740    168     1.474     3416  1.695   248    .021         71.742   .036     5.200
  SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      129.946   .539  1654.046
CYCLE 4
  1 IDLE        156  1.010  13.480    130     1.024      160  1.035   133    .036          5.753   .037     4.795
  2 16'HG        76   .180  13.180   1350     1.086       83   .195  1466    .089          7.396   .017   130.480
  3 10'HG        45   .180  13.180   1784     1.089       49   .196  1942    .257         12.591   .050   499.157
  4 16'HG        40   .180  13.180   1313     1.089       44   .196  1430    .089          3.877   .017   127.274
  5 19'HG        31   .180  13.400    600     1.072       33   .193   643    .047          1.562   .009    30.236
  6 16'HG        40   .180  13.180   1444     1.089       44   .196  1573    .089          3.877   .017   139.973
  7  3'HG        78  1.320  13.630   2099     1.009       79  1.332  2117    .283         22.267   .377   599.214
  8 16'HG        36   .180  13.330   1545     1.077       39   .194  1665    .089          3.452   .017   148.142
  9 C.T.       2288  1.040   6.790    131     1.482     3392  1.542   194    .021         71.229   .032     4.078
  SUM-----------(CYCLE COMPOSITE)--------------------------------------------------      131.955   .575  1683.349
 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------      154.609   .541  1582.779

 AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------      130.951   .557  1668.697

 FOUR CYCLE COMPOSITE - REPORTED VALUES -   HC    0.35*(  154.609) + 0.65*(  130.951) =   139.231  PPM
                                            CO    0.35*(     .541) + 0.65*(     .557) =      .552  PERCENT
                                            NO    0.35*( 1582.779) + 0.65*( 1668.697) =  1638.626  PPM
                                                                   CORRECTED NO =  1690.037  PPM

 DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
         8-4-72   RUN 3 2-4 48TDC 600RPM  E.R.L STD.ENG.   STA.                 K =1.031     HUM =  84  GR/LB
         ----------------------------------------------------------------------------------------------------------------
         FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING        W E I G H T E D
         MODE            HC      CO     CO2     NO     FACTOR     HC      CO    NO      FACTOR        HC      CO        NO
         ----------------------------------------------------------------------------------------------------------------
CYCLE 1
         1 IDLE         272   1.380  13.060    105     1.032     281   1.425   108      .036       10.110    .051      3.903
         2 16'HG         80    .210  13.210   1340     1.082      87    .227  1450      .089        7.704    .020    129.037
         3 10'HG         48    .220  13.220   1698     1.084      52    .238  1840      .257       13.367    .061    472.850
         4 16'HG         46    .240  13.180   1406     1.086      50    .261  1527      .089        4.447    .023    135.917
         5 19'HG         28    .240  13.330    560     1.076      30    .258   602      .047        1.416    .012     28.311
         6 16'HG         42    .240  13.190   1387     1.087      46    .261  1507      .089        4.061    .023    134.123
         7  3'HG         80   1.380  13.630   2121     1.006      81   1.389  2135      .283       22.787    .393    604.143
         8 16'HG         35    .250  13.250   1530     1.091      38    .270  1654      .089        3.367    .024    147.208
         9 C.T.        1868   1.200   8.220    115     1.338    2499   1.606   154      .021       52.485    .034      3.231
         SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------  119.744    .642   1658.721
CYCLE 2
         1 IDLE         272   1.380  13.060    105     1.032     281   1.425   108      .036       10.110    .051      3.903
         2 16'HG         77    .230  13.110   1332     1.090      84    .251  1451      .089        7.467    .022    129.165
         3 10'HG         48    .210  13.330   1925     1.075      52    .226  2070      .257       13.263    .058    531.890
         4 16'HG         44    .220  13.330   1425     1.075      47    .237  1532      .089        4.210    .021    136.345
         5 19'HG         31    .220  13.330    628     1.076      33    .237   676      .047        1.568    .011     31.765
         6 16'HG         40    .220  13.180   1501     1.088      44    .239  1632      .089        3.872    .021    145.279
         7  3'HG         77   1.450  13.480   2099     1.015      78   1.471  2130      .283       22.114    .416    602.824
         8 16'HG         31    .250  13.180   1559     1.087      34    .272  1695      .089        2.999    .024    150.833
         9 C.T.        1813   1.250   9.040    131     1.248    2262   1.559   163      .021       47.497    .033      3.432
         SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------  113.099    .658   1735.437
CYCLE 3
         1 IDLE         159   1.140  13.480    150     1.020     162   1.162   153      .036        5.836    .042      5.506
         2 16'HG         77    .220  13.180   1369     1.084      83    .239  1484      .089        7.430    .021    132.107
         3 10'HG         48    .210  13.330   1947     1.075      52    .226  2093      .257       13.263    .058    537.969
         4 16'HG         44    .210  13.180   1406     1.088      48    .228  1529      .089        4.259    .020    136.092
         5 19'HG         31    .210  13.390    674     1.072      33    .225   722      .047        1.562    .011     33.953
         6 16'HG         41    .210  13.180   1534     1.088      45    .228  1674      .089        3.969    .020    149.001
         7  3'HG         80   1.450  13.390   2077     1.021      82   1.480  2121      .283       23.116    .419    600.150
         8 16'HG         32    .250  13.060   1490     1.097      35    .274  1634      .089        3.124    .024    145.455
         9 C.T.        1772   1.150   9.200    142     1.241    2198   1.427   176      .021       46.162    .030      3.699
         SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------  108.721    .646   1743.931
CYCLE 4
         1 IDLE         159   1.140  13.480    150     1.020     162   1.162   153      .036        5.836    .042      5.506
         2 16'HG         77    .220  13.180   1388     1.084      83    .239  1505      .089        7.430    .021    133.941
         3 10'HG         48    .210  13.060   1969     1.097      53    .230  2159      .257       13.534    .059    554.879
         4 16'HG         44    .220  13.190   1490     1.087      48    .239  1620      .089        4.257    .021    144.168
         5 19'HG         31    .220  13.330    628     1.076      33    .237   676      .047        1.568    .011     31.765
         6 16'HG         41    .250  13.180   1444     1.086      45    .272  1568      .089        3.964    .024    139.594
         7  3'HG         77   1.430  13.480   2121     1.016      78   1.452  2154      .283       22.130    .411    609.569
         8 16'HG         35    .250  13.190   1618     1.087      38    .272  1758      .089        3.385    .024    156.491
         9 C.T.        1750   1.070   9.170    115     1.251    2188   1.338   144      .021       45.957    .028      3.020
         SUM-----------(CYCLE COMPOSITE)---------------------------------------------------------  108.061    .642   1778.933

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)---------------------------------------  116.422    .650   1697.079

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)---------------------------------------  108.391    .644   1761.432

         FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  116.422) + 0.65*(  108.391) =    111.202  PPM
                                                     CO    0.35*(     .650) + 0.65*(     .644) =       .646  PERCENT
                                                     NO    0.35*( 1697.079) + 0.65*( 1761.432) =   1738.909  PPM
                                                                                 CORRECTED NO =   1793.466  PPM

         DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
8-4-72   RUN 1 2-3 4HTDC 600RP4  F.R.L STD.ENG.   STA.                K = 1.03     HUM =  84  GR/LB
--------------------------------------------------------------------------------------------------------------
MASS           CONCENTRATION AS MEASURED      TOTAL    FUEL      ADJUSTED (MASS)       WT.       WEIGHTED (MASS)
MODE          HC      CO     CO2      NO     CARBON   CONS.      HC      CO    NO2    FACT.     HC      CO   NO2(K)  HP
--------------------------------------------------------------------------------------------------------------

CYCLE 1
       1 IDLE    148    .800  13.48     105  14.440    1543      17     173      4   .232      4.0     40     .9    0
       2 16 HG    43    .180  13.77    1135  14.050    7173      51     186    192   .077      3.9     14   14.8   26
       3 10 HG    49    .180  13.77    1377  14.003   11895      45     309    388   .147      6.6     45   57.1   51
       4 16 HG    40    .180  13.77     956  13.993    7173      22     186    163   .077      1.7     14   12.5   26
       5 19 HG    26    .180  13.77     393  13.978    6084      12     158     57   .057       .7      9    3.2   15
       6 16 HG    40    .180  13.63    1085  13.853    7173      22     188    187   .077      1.7     14   14.4   26
       7  3 HG    75   1.110  14.31    1434  15.501   18796      98    2719    781   .113     11.1    307   88.2   88
       8 16 HG    35    .180  14.42    1371  14.638    7173      19     178    223   .077      1.4     14   17.2   26
       9 C.T.   1712    .950   8.13     129  10.929    1589     269     279      6   .143     38.4     40     .9    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      2.7     19    8.0

CYCLE 2
       1 IDLE    148    .800  13.48     105  14.440    1543      17     173      4   .232      4.0     40     .9    0
       2 16 HG    76    .180  13.77    1036  14.032    7173      42     186    176   .077      3.2     14   13.5   26
       3 10 HG    49    .180  13.91    1599  14.143   11895      45     306    446   .147      6.5     45   65.6   51
       4 16 HG    44    .180  13.91    1185  14.138    7173      24     184    200   .077      1.9     14   15.4   26
       5 19 HG    26    .180  13.91     501  14.118    6084      12     157     72   .057       .7      9    4.1   15
       6 16 HG    40    .180  13.77    1236  13.993    7173      22     186    210   .077      1.7     14   16.2   26
       7  3 HG    76   1.160  14.31    1939  15.552   18796      99    2832    778   .113     11.2    320   87.9   88
       8 16 HG    35    .180  14.05    1431  14.268    7173      19     183    239   .077      1.5     14   18.4   26
       9 C.T.   1661    .980   8.94     147  11.714    1589     243     269      7   .143     34.8     38     .9    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      2.5     19    8.5

CYCLE 3
       1 IDLE     89   1.170  14.18     165  15.446    1543      10     236      5   .232      2.2     55    1.3    0
       2 16 HG    80    .180  13.91    1185  14.176    7173      44     184    199   .077      3.4     14   15.3   26
       3 10 HG    48    .180  14.05    1676  14.282   11895      43     303    463   .147      6.3     45   68.1   51
       4 16 HG    44    .180  14.05    1224  14.278    7173      24     183    204   .077      1.8     14   15.7   26
       5 19 HG    31    .180  14.05     542  14.263    6084      14     155     77   .057       .8      9    4.4   15
       6 16 HG    44    .180  14.05    1306  14.278    7173      24     183    218   .077      1.8     14   16.8   26
       7  3 HG    80   1.200  14.31    1939  15.596   18796     104    2921    776   .113     11.8    330   87.7   88
       8 16 HG    35    .210  14.05    1389  14.298    7173      19     213    231   .077      1.5     16   17.8   26
       9 C.T.   1624    .900   9.10     168  11.754    1589     237     246      8   .143     33.9     35    1.1    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      2.4     20    8.7

CYCLE 4
       1 IDLE     89   1.170  14.18     165  15.446    1543      10     236      5   .232      2.2     55    1.3    0
       2 16 HG    71    .180  13.91    1195  14.167    7173      39     184    201   .077      3.0     14   15.5   26
       3 10 HG    48    .180  14.05    1702  14.292   11895      43     303    471   .147      6.3     45   69.2   51
       4 16 HG    44    .180  13.96    1202  14.188    7173      24     184    202   .077      1.8     14   15.5   26
       5 19 HG    31    .180  14.05     501  14.263    6084      14     155     71   .057       .8      9    4.0   15
       6 16 HG    44    .180  14.05    1306  14.278    7173      24     183    218   .077      1.8     14   16.8   26
       7  3 HG    77   1.200  14.42    1982  15.703   18796     100    2901    788   .113     11.2    328   89.0   88
       8 16 HG    25    .190  14.05    1468  14.267    7173      14     193    245   .077      1.0     15   18.9   26
       9 C.T.   1603    .850   9.07     127  11.651    1589     236     234      6   .143     33.8     33     .8    0
       SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      2.4     20    8.8

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------      2.6     19    8.2

       AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------      2.4     20    8.8

       FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.6) + 0.65(     2.4) =    2.461  (MASS)
                                                CO  0.35(      19) + 0.65(      20) =     19.9  (MASS)
                                                NO2 0.35(     8.2) + 0.65(     8.8) =    8.579  (MASS)
                                                            CORRECTED NO2 =    8.808  (MASS)
```

```
 8-4-72   RUN 2 2-3 44TDC 600RPM  E.F.I STD.ENG.   STA.               K = 1.03     HUM =  84  GR/LB
---------------------------------------------------------------------------------------------------------------
MASS          CONCENTRATION AS MEASURED     TOTAL    FUEL     ADJUSTED (MASS)        WT.      WEIGHTED (MASS)
MODE           HC      CO      CO2     NO   CARBON   CONS.     HC      CO     NO2   FACT.    HC       CO   NO2(K)  HP
---------------------------------------------------------------------------------------------------------------

CYCLE 1
  1 IDLE       427    .810   12.22     90   13.491    1543     53     187      3   .232    12.2      43     .8    0
  2 16 HG      120    .180   12.09   1444   12.400    7173     75     210    277   .077     5.8      16   21.4   26
  3 10 HG       62    .180   13.06   1463   13.307   11895     60     325    434   .147     8.8      48   63.8   51
  4 16 HG       49    .180   12.94   1031   13.173    7173     29     198    186   .077     2.2      15   14.4   26
  5 19 HG       36    .180   12.34    450   12.559    6084     19     176     72   .057     1.1      10    4.1   15
  6 16 HG       40    .180   12.92   1117   13.148    7173     26     198    202   .077     2.0      15   15.6   26
  7  3 HG       80   1.090   13.63   2040   14.806   18796    110    2795    860   .113    12.4     316   97.2   88
  8 16 HG       42    .210   13.18   1520   13.435    7173     24     226    269   .077     1.9      17   20.7   26
  9 C.T.      2444   1.100    6.56    133   10.300    1589    407     343      7   .143    58.2      49    1.0    0
  SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     4.0      20    9.1

CYCLE 2
  1 IDLE       427    .810   12.22     90   13.491    1543     53     187      3   .232    12.2      43     .8    0
  2 16 HG       79    .180   13.06   1170   13.325    7173     46     196    209   .077     3.5      15   16.1   26
  3 10 HG       49    .180   13.18   1625   13.413   11895     47     322    478   .147     6.9      47   70.3   51
  4 16 HG       45    .180   13.18   1313   13.409    7173     26     195    233   .077     2.0      15   18.0   26
  5 19 HG       31    .180   13.33    582   13.543    6084     15     163     87   .057      .9       9    4.9   15
  6 16 HG       45    .180   13.18   1292   13.409    7173     26     195    229   .077     2.0      15   17.7   26
  7  3 HG       76   1.300   13.63   2130   15.012   18796    103    3288    885   .113    11.6     372  100.1   88
  8 16 HG       40    .180   13.33   1625   13.553    7173     23     192    286   .077     1.8      15   22.0   26
  9 C.T.      2372   1.090    6.75    152   10.402    1589    391     336      8   .143    56.0      48    1.1    0
  SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.7      22    9.6

CYCLE 3
  1 IDLE       156   1.010   13.48    130   14.658    1543     18     215      5   .232     4.1      50    1.1    0
  2 16 HG       70    .180   13.85   1295   14.106    7173     38     185    219   .077     3.0      14   16.8   26
  3 10 HG       45    .180   13.94   1759   14.169   11895     41     305    490   .147     6.0      45   72.1   51
  4 16 HG       45    .180   13.94   1392   14.169    7173     25     184    234   .077     1.9      14   18.0   26
  5 19 HG       31    .180   14.03    620   14.243    6084     14     155     88   .057      .8       9    5.0   15
  6 16 HG       37    .180   13.98   1539   14.200    7173     20     184    258   .077     1.6      14   19.9   26
  7  3 HG       76   1.200   13.63   2143   14.912   18796    103    3055    897   .113    11.7     345  101.3   88
  8 16 HG       36    .180   13.94   1598   14.159    7173     20     184    269   .077     1.5      14   20.7   26
  9 C.T.      2318   1.150    6.76    148   10.413    1589    382     354      9   .143    54.6      51    1.2    0
  SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.2      21    9.8

CYCLE 4
  1 IDLE       156   1.010   13.48    130   14.658    1543     18     215      5   .232     4.1      50    1.1    0
  2 16 HG       76    .180   13.18   1350   13.442    7173     44     194    239   .077     3.4      15   18.4   26
  3 10 HG       45    .180   13.18   1784   13.409   11895     43     323    525   .147     6.3      47   77.2   51
  4 16 HG       40    .180   13.18   1313   13.403    7173     23     195    233   .077     1.8      15   18.0   26
  5 19 HG       31    .180   13.40    600   13.613    6084     15     162     89   .057      .9       9    5.1   15
  6 16 HG       40    .180   13.18   1444   13.403    7173     23     195    257   .077     1.8      15   19.8   26
  7  3 HG       78   1.320   13.63   2099   15.034   18796    105    3334    871   .113    11.9     377   98.4   88
  8 16 HG       36    .180   13.33   1545   13.549    7173     21     192    272   .077     1.6      15   20.9   26
  9 C.T.      2288   1.040    6.79    131   10.301    1589    381     324      7   .143    54.5      46    1.0    0
  SUM------------(CYCLE COMPOSITE)-----------------------------------------------------     3.3      22    9.9

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------     3.8      21    9.3

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------     3.3      22    9.8

  FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     3.8) + 0.65(      3.3) =    3.471  (MASS)
                                           CO  0.35(      21) + 0.65(       22) =     21.6  (MASS)
                                           NO2 0.35(     9.3) + 0.65(      9.8) =    9.669  (MASS)
                                                              CORRECTED NO2 =    9.928  (MASS)
```

```
5-4-72   RUN 3 2-3 4M10C 600RPM  F.R.L STD.ENG.   STA.              K = 1.03     HUM =  84  GR/LB
-----------------------------------------------------------------------------------------------------------
MASS        CONCENTRATION AS MEASURED      TOTAL    FUEL       ADJUSTED (MASS)        WT.       WEIGHTED (MASS)
MODE          HC      CO     CO2     NO   CARBON   CONS.      HC      CO    NO2   FACT.      HC       CO   NO2(K)  HP
-----------------------------------------------------------------------------------------------------------
CYCLE 1
   1 IDLE     272   1.380  13.06    105   14.734    1543      31     292      4   .232      7.1      68      .8    0
   2 16 MG     80    .210  13.21   1340   13.506    7173      46     225    236   .077      3.5      17    18.2   26
   3 10 MG     48    .220  13.22   1698   13.492   11845      46     392    497   .147      6.7      58    73.1   51
   4 16 MG     46    .240  13.18   1406   13.470    7173      26     258    249   .077      2.0      20    19.1   26
   5 19 MG     28    .240  13.33    560   13.600    6084      14     217     83   .057       .8      12     4.7   15
   6 16 MG     42    .240  13.18   1387   13.465    7173      24     258    245   .077      1.9      20    18.9   26
   7  3 MG     80   1.380  13.63   2121   15.096   18796     108    3471    877   .113     12.2     392    99.1   88
   8 16 MG     35    .250  13.25   1530   13.538    7173      20     268    269   .077      1.5      21    20.7   26
   9 C.T.    1868   1.200   8.22    115   11.437    1589     280     337      5   .143     40.1      48      .8    0
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------      2.9      25     9.7
CYCLE 2
   1 IDLE     272   1.380  13.06    105   14.734    1543      31     292      4   .232      7.1      68      .8    0
   2 16 MG     77    .230  13.11   1332   13.423    7173      44     248    236   .077      3.4      19    18.2   26
   3 10 MG     48    .210  13.33   1425   13.542   11895      45     371    559   .147      6.7      55    82.2   51
   4 16 MG     44    .220  13.33   1425   13.598    7173      25     234    250   .077      1.9      18    19.2   26
   5 19 MG     31    .220  13.33    628   13.583    6084      15     199     93   .057       .9      11     5.3   15
   6 16 MG     40    .220  13.18   1501   13.443    7173      23     237    266   .077      1.8      18    20.5   26
   7  3 MG     77   1.450  13.48   2099   15.013   18796     104    3667    872   .113     11.8     414    98.6   88
   8 16 MG     31    .250  13.18   1559   13.463    7173      18     269    276   .077      1.4      21    21.2   26
   9 C.T.    1813   1.250   9.04    131   12.248    1589     254     328      6   .143     36.3      47      .8    0
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------      2.7      26    10.2
CYCLE 3
   1 IDLE     159   1.140  13.48    150   14.792    1543      18     240      5   .232      4.2      56     1.2    0
   2 16 MG     77    .220  13.18   1369   13.483    7173      44     236    242   .077      3.4      18    18.6   26
   3 10 MG     48    .210  13.33   1947   13.592   11895      45     371    566   .147      6.7      55    83.2   51
   4 16 MG     44    .210  13.18   1406   13.438    7173      25     226    249   .077      2.0      17    19.2   26
   5 19 MG     31    .210  13.39    674   13.633    6084      15     189    100   .057       .9      11     5.7   15
   6 16 MG     41    .210  13.18   1539   13.434    7173      24     226    273   .077      1.8      17    21.0   26
   7  3 MG     80   1.450  13.39   2077   14.926   18796     109    3688    868   .113     12.3     417    98.1   88
   8 16 MG     32    .250  13.06   1490   13.345    7173      19     271    266   .077      1.4      21    20.5   26
   9 C.T.    1772   1.150   9.20    142   12.264    1589     248     301      6   .143     35.5      43      .9    0
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------      2.6      25    10.2
CYCLE 4
   1 IDLE     159   1.140  13.48    150   14.792    1543      18     240      5   .232      4.2      56     1.2    0
   2 16 MG     77    .220  13.18   1388   13.483    7173      44     236    245   .077      3.4      18    18.9   26
   3 10 MG     48    .210  13.06   1968   13.322   11895      46     379    583   .147      6.8      56    85.8   51
   4 16 MG     44    .220  13.18   1490   13.448    7173      25     237    264   .077      2.0      18    20.3   26
   5 19 MG     31    .220  13.33    628   13.583    6084      15     199     93   .057       .9      11     5.3   15
   6 16 MG     41    .250  13.18   1444   13.474    7173      24     269    255   .077      1.8      21    19.7   26
   7  3 MG     77   1.430  13.48   2121   14.993   18796     104    3621    883   .113     11.8     409    99.8   88
   8 16 MG     35    .250  13.18   1618   13.468    7173      20     269    286   .077      1.6      21    22.0   26
   9 C.T.    1750   1.070   9.17    115   12.130    1584     248     283      5   .143     35.4      40      .7    0
   SUM------------(CYCLE COMPOSITE)--------------------------------------------------      2.6      25    10.4

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------      2.8      25    10.0

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------      2.6      25    10.3

   FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.8) + 0.65(     2.6) =    2.666  (MASS)
                                            CO  0.35(      25) + 0.65(      25) =     25.0  (MASS)
                                            NO2 0.35(    10.0) + 0.65(    10.3) =   10.209  (MASS)
                                                               CORRECTED NO2 =   10.482  (MASS)
```

```
[illegible] FOR OXIDATION CATALYST          K =1.051      HUM =  90  GR/LB
------------------------------------------------------------------------------------------------------------------
         FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION    A D J U S T E D    WEIGHTING      W E I G H T E D
         MODE           HC     CO     CO2     NO      FACTOR    HC     CO    NO      FACTOR     HC      CO       NO
------------------------------------------------------------------------------------------------------------------
CYCLE 1
         1 IDLE         65   .220   9.410     52      1.512     98   .333    79      .036      3.538   .012     2.830
         2 16'HG       521   .340   8.210     77      1.621    845   .551   125      .089     75.184   .049    11.112
         3 10'HG        35   .180  10.450    146      1.309     46   .236   191      .257     11.774   .061    49.113
         4 16'HG        76   .080   9.060    103      1.579    120   .126   163      .089     10.681   .011    14.476
         5 19'HG       612   .070   7.180     64      1.841   1127   .129   118      .047     52.956   .006     5.538
         6 16'HG        60   .100   9.210     77      1.555     93   .155   120      .089      8.304   .014    10.656
         7  3'HG        21   .140  13.200   1482      1.091     23   .153  1617      .283      6.483   .043   457.499
         8 16'HG        21   .100   9.370    103      1.536     32   .154   158      .084      2.870   .014    14.077
         9 C.T.        320   .110   4.730     69      2.826    904   .311   195      .021     18.992   .007     4.095
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  190.782   .216   569.397
CYCLE 2
         1 IDLE         65   .220   9.410     52      1.512     98   .333    79      .036      3.538   .012     2.830
         2 16'HG       176   .080   8.780     90      1.609    283   .129   145      .089     25.208   .011    12.891
         3 10'HG        13   .100  10.780    210      1.337     17   .134   281      .257      4.467   .034    72.165
         4 16'HG        48   .100   9.140    100      1.569     75   .157   157      .089      6.703   .014    13.964
         5 19'HG       642   .070   7.230     64      1.822   1170   .128   117      .047     54.977   .006     5.481
         6 16'HG        66   .090   9.250     77      1.548    102   .139   119      .089      9.094   .012    10.609
         7  3'HG        13   .130  13.330   1453      1.081     14   .141  1582      .283      3.978   .040   447.714
         8 16'HG        17   .070   9.370    103      1.539     26   .108   158      .089      2.328   .010    14.106
         9 C.T.        318   .110   4.690     73      2.850    906   .313   208      .021     19.030   .007     4.368
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  129.322   .146   584.128
CYCLE 3
         1 IDLE          8   .070   9.250     77      1.560     12   .109   120      .036       .449   .004     4.325
         2 16'HG       138   .070   8.930     74      1.591    220   .111   118      .089     19.540   .010    10.478
         3 10'HG         8   .100  10.780    224      1.338     11   .134   300      .257      2.751   .034    77.015
         4 16'HG        57   .070   9.030    103      1.589     91   .111   164      .089      8.060   .010    14.564
         5 19'HG       715   .090   7.000     64      1.855   1326   .167   119      .047     62.333   .008     5.579
         6 16'HG        70   .090   9.180     77      1.559    109   .140   120      .089      9.713   .012    10.684
         7  3'HG        17   .130  13.180   1510      1.093     19   .142  1651      .283      5.260   .040   467.173
         8 16'HG        16   .070   9.190    104      1.569     25   .110   171      .089      2.234   .010    15.220
         9 C.T.        317   .100   4.390     72      3.032    961   .303   218      .021     20.184   .006     4.584
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  130.523   .135   609.623
CYCLE 4
         1 IDLE          8   .070   9.250     77      1.560     12   .109   120      .036       .449   .004     4.325
         2 16'HG       103   .070   9.140    103      1.561    161   .109   161      .089     14.314   .010    14.314
         3 10'HG         8   .070  10.780    237      1.340     11   .094   317      .257      2.754   .024    81.597
         4 16'HG        50   .070   9.140    103      1.571     79   .110   162      .089      6.992   .010    14.403
         5 19'HG       671   .070   7.090     77      1.847   1239   .129   142      .047     58.255   .006     6.685
         6 16'HG        73   .070   9.140     77      1.567    114   .110   121      .089     10.180   .010    10.738
         7  3'HG        13   .110  13.180   1463      1.094     14   .120  1601      .283      4.026   .034   453.121
         8 16'HG        13   .070   9.190    117      1.569     20   .110   184      .089      1.816   .010    16.342
         9 C.T.        325   .090   4.610     73      2.897    941   .261   211      .021     19.769   .005     4.440
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  118.556   .113   605.966

         AVEPAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------  160.052   .181   576.762

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------  124.540   .124   607.794

         FOUR CYCLE COMPOSITE - REPORTED VALUES -   HC   0.35*(  160.052) + 0.65*(  124.540) =   136.969  PPM
                                                    CO   0.35*(     .181) + 0.65*(     .124) =      .144  PERCENT
                                                    NO   0.35*(  576.762) + 0.65*(  607.794) =   596.933  PPM
                                                                              CORRECTED NO =   627.221  PPM

         DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

APPENDIX Q

ENGINE 1-3

EFFECT OF BASIC SPARK TIMING ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 1-3

EFFECT OF BASIC SPARK TIMING ON EMISSIONS

TABULAR DATA

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-17-72 RUN-2 ENG.1-3 72-VERSION  30 BTDC
--------------------------------------------------------------------------------------
            DYNA.         MAN. FUEL    A/F                  DRY CONCENTRATION
MODE SPEED  LOAD    HP   VAC. LB/HR   RATIO   ALDE.     HC        CO        CO2     NO
--------------------------------------------------------------------------------------
  1   600      0.0    0  18.8    3.5   16.5          0 15522   2.600     10.89     49
  2  1200      5.0    1  20.5    6.9   18.2          0 15570    .520     11.60    163
  3  1200     20.0    5  18.0    9.2   19.1          0 29138    .150      9.50   1125
  4  1200     44.0   10  16.2   10.4   19.4          0 17064    .130     10.78   1700
  5  1200     62.0   14  15.0   11.8   19.5          0 14078    .130     11.13   2213
  6  1200    123.0   28  10.1   16.3   19.6          0  2649    .130     12.34   4100
  7  1200    185.0   42   5.0   21.4   19.2          0  2098    .130     12.71   4600
  8  1200    202.0   46   3.9   22.2   19.1          0  1994    .130     12.82   4650
  9  1200    226.0   52   1.9   24.5   18.7          0  2172    .180     12.94   4250
 10  1200    246.0   56    .3   34.4   14.4          0  3833   5.720     11.24    800
 11   600      0.0    0  18.8    3.5   16.2          0 12687   2.870     11.48     55
 12  1200      0.0    0  22.5    3.7   20.8          0 52581    .310      5.27     29
 13  2300    258.0  113   1.3   65.4   14.4          0  2806   5.400     11.60   1000
 14  2300    237.0  104   2.3   54.5   16.0          0  1778   2.870     12.22   2750
 15  2300    212.0   93   2.7   48.7   17.7          0  1195   1.450     12.34   2125
 16  2300    194.0   85   4.2   45.5   17.9          0  1330   1.160     12.59   2550
 17  2300    129.0   56  10.3   33.8   17.9          0  1620    .420     13.06   4550
 18  2300     65.0   28  15.3   22.7   18.5          0  4082    .210     12.59   2850
 19  2300     46.0   20  16.2   21.4   18.6          0  6695    .180     12.34   2250
 20  2300     21.0    9  17.8   18.4   19.4          0 12817    .210     11.13   1250
 21  2300      5.0    2  18.7   15.4   19.9          0 23381    .210      9.25    740
 22   600      0.0    0  18.7    3.4   17.0          0 20053   2.080     10.25     60
 23  2300      0.0    0  24.3    4.2   23.9          0 36871    .280      5.50     12
--------------------------------------------------------------------------------------
        CALCULATED GRAM/HR         WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC      CO     NO2  FAC.      HP  ALDE.      HC       CO     NO2
--------------------------------------------------------------------------------------
  1   0.0  163.8     554     1.7  .070     0.0     I        R        R       R
  2   0.0  356.3     240    12.4  .060      .1   0.0  311.88    210.4    10.8
  3   0.0  967.8     101   124.1  .060      .3   0.0  211.79     22.0    27.1
  4   0.0  638.1      98   211.0  .050      .5   0.0   63.47      9.8    21.0
  5   0.0  594.8     111   310.4  .030      .4   0.0   41.99      7.8    21.9
  6   0.0  153.8     152   790.3  .060     1.7   0.0    5.47      5.4    28.1
  7   0.0  156.0     195  1136.0 0.000     0.0   0.0    3.69      4.6    26.9
  8   0.0  152.7     201  1182.3  .040     1.8   0.0    3.31      4.4    25.6
  9   0.0  181.0     303  1175.7 0.000     0.0   0.0    3.50      5.9    22.8
 10   0.0  344.8   10396   239.0 0.000     0.0   0.0    6.14    185.0     4.3
 11   0.0  129.0     589     1.9  .070     0.0     I        R        R       R
 12   0.0  814.2      97     1.5  .120     0.0     I        R        R       R
 13   0.0  481.8   18726   569.9  .025     2.8   0.0    4.26    165.7     5.0
 14   0.0  287.8    9387  1478.3  .055     5.7   0.0    2.77     90.4    14.2
 15   0.0  189.8    4652  1120.4  .035     3.2   0.0    2.04     50.1    12.1
 16   0.0  197.7    3483  1258.6  .060     5.1   0.0    2.33     41.0    14.8
 17   0.0  182.0     953  1697.7  .060     3.4   0.0    3.22     16.9    30.1
 18   0.0  318.2     331   737.6 0.000     0.0   0.0   11.18     11.6    25.9
 19   0.0  492.7     268   549.8  .065     1.3   0.0   24.46     13.3    27.3
 20   0.0  847.5     281   274.4 0.000     0.0   0.0   92.16     30.5    29.8
 21   0.0 1384.4     251   145.5 0.000     0.0   0.0  632.23    114.7    66.4
 22   0.0  215.7     452     2.1  .080     0.0     I        R        R       R
 23   0.0  742.0     114      .8  .060     0.0     I        R        R       R

CYCLE COMPOSITE    HC     15.687   GRAM/BHP HR
                   CO     61.081   GRAM/BHP HR
                   NO2    17.864   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .669     LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-17-72 RUN-1 ENG.1-3 72-VERSION  15 BTDC
--------------------------------------------------------------------------------
              DYNA.       MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO   ALDE.     HC      CO      CO2     NO
--------------------------------------------------------------------------------
   1   600     0.0     0  19.1   3.5   16.2        0  6038   3.330   11.72    55
   2  1200     5.0     1  20.2   7.4   17.9        0  1829    .490   13.48    80
   3  1200    20.0     5  19.5   8.0   17.9        0  2539    .420   13.48   205
   4  1200    45.0    10  17.7   9.5   18.5        0  2695    .210   13.06   575
   5  1200    62.0    14  15.7  11.0   19.0        0  2280    .150   12.71   880
   6  1200   124.0    28  10.3  16.3   19.4        0  2136    .150   12.47  1912
   7  1200   186.0    42   4.0  22.2   19.0        0  1761    .150   12.59  2150
   8  1200   203.0    46   2.4  23.5   18.7        0  2015    .180   12.71  2300
   9  1200   228.0    52   1.8  26.8   17.1        0  2771   1.120   13.06  2125
  10  1200   248.0    57    .3  34.4   13.9        0  4396   6.640   11.13   570
  11   600     0.0     0  18.9   3.3   15.0        0  6031   4.840   11.24    42
  12  1200     0.0     0  22.8   3.5   19.5        0 53466    .470    5.88    10
  13  2300   262.0   115   1.3  66.2   14.5        0  3256   5.240   11.24   750
  14  2300   241.0   106   2.3  60.1   15.2        0  2577   3.790   11.92  1432
  15  2300   215.0    94   2.5  53.0   16.6        0  1134   2.020   12.47  1150
  16  2300   197.0    86   2.7  49.1   17.5        0   708   1.120   12.34  1063
  17  2300   131.0    57  10.2  33.6   17.7        0  1550    .350   12.94  7950
  18  2300    66.0    29  15.1  23.3   18.2        0  1153    .180   12.71  1662
  19  2300    47.0    21  16.4  20.7   18.6        0   850    .150   12.59  1125
  20  2300    21.0     9  18.2  17.2   18.9        0   893    .150   12.47   570
  21  2300     5.0     2  19.8  13.5   19.3        0  6313    .150   11.48   210
  22   600     0.0     0  18.9   3.4   16.1        0  3852   2.520   11.84    49
  23  2300     0.0     0  24.3   3.8   22.3        0 38526    .250    5.75    10
--------------------------------------------------------------------------------
        CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC       CO     NO2
--------------------------------------------------------------------------------
   1   0.0   61.2      682     1.9  .070     0.0      I       R        R       R
   2   0.0   43.4      235     6.3  .060      .1    0.0   37.98    205.5     5.5
   3   0.0   65.1      218    17.4  .060      .3    0.0   14.25     47.6     3.8
   4   0.0   85.8      135    60.8  .050      .5    0.0    8.34     13.1     5.9
   5   0.0   86.9      116   111.4  .030      .4    0.0    6.14      8.2     7.9
   6   0.0  123.1      175   365.8  .060     1.7    0.0    4.34      6.2    12.9
   7   0.0  137.3      236   556.5 0.000     0.0    0.0    3.23      5.6    13.1
   8   0.0  164.0      296   621.8  .040     1.9    0.0    3.54      6.4    13.4
   9   0.0  233.0     1902   593.2 0.000     0.0    0.0    4.47     36.5    11.4
  10   0.0  376.7    11493   162.2 0.000     0.0    0.0    6.65    202.8     2.9
  11   0.0   54.1      877     1.3  .070     0.0      I       R        R       R
  12   0.0  725.7      129      .5  .120     0.0      I       R        R       R
  13   0.0  581.7    18913   444.9  .025     2.9    0.0    5.07    164.8     3.9
  14   0.0  440.0    13071   814.8  .055     5.8    0.0    4.17    123.8     7.7
  15   0.0  186.7     6717   628.5  .035     3.3    0.0    1.98     71.3     6.7
  16   0.0  116.6     3724   580.6  .060     5.2    0.0    1.35     43.2     6.7
  17   0.0  175.7      801  2992.0  .060     3.4    0.0    3.06     14.0    52.2
  18   0.0   93.7      295   448.5 0.000     0.0    0.0    3.24     10.2    15.5
  19   0.0   62.2      222   273.5  .065     1.3    0.0    3.02     10.8    13.3
  20   0.0   54.8      186   116.2 0.000     0.0    0.0    5.96     20.2    12.6
  21   0.0  315.3      151    34.8 0.000     0.0    0.0  143.99     69.1    15.9
  22   0.0   40.3      532     1.7  .080     0.0      I       R        R       R
  23   0.0  674.0       88      .6  .060     0.0      I       R        R       R

CYCLE COMPOSITE     HC      8.707    GRAM/BHP HR
                    CO     72.676    GRAM/BHP HR
                    NO2    13.644    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .679      LB/BHP HR
```

```
                   PROJECT 11-2877-01  CONTROL TECHNOLOGY
     8-16-72 RUN-2 ENG.1-3 72-VERSION  6 BTDC
----------------------------------------------------------------------------
                DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED      LOAD    HP   VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2     NO
----------------------------------------------------------------------------
   1   600       0.0     0   17.4   4.3   14.9       0  3793   1.590   12.71     49
   2  1200       5.0     1   19.8   7.8   15.8       0  1240    .250   13.48     86
   3  1200      19.0     4   19.0   8.4   15.9       0  2024    .250   13.18    245
   4  1200      42.0    10   16.8  10.3   16.4       0  1842    .130   13.18    520
   5  1200      58.0    13   16.2  10.5   16.6       0  1917    .150   12.94    580
   6  1200     116.0    27   10.7  15.6   16.9       0  2049    .100   12.82   1512
   7  1200     174.0    40    3.6  22.8   16.5       0  1603    .130   12.94   1700
   8  1200     190.0    43    2.1  24.5   16.3       0  1706    .150   13.06   2012
   9  1200     213.0    49    1.8  26.9   14.9       0  2414   1.050   13.63   1900
  10  1200     232.0    53     .4  34.2   12.4       0  4019   5.780   11.13    565
  11   600       0.0     0   17.3   3.5   14.1       0  4219   2.440   12.71     53
  12  1200       0.0     0   22.0   4.1   17.5       0 51519    .350    6.38     10
  13  2300     252.0   110    1.3  66.3   12.6       0  3352   5.140   11.72    765
  14  2300     232.0   102    2.3  60.2   13.2       0  2406   3.980   12.47   1412
  15  2300     207.0    91    2.5  53.4   14.5       0   994   2.050   12.71   1075
  16  2300     189.0    83    2.8  49.4   15.5       0   474    .970   12.94   1012
  17  2300     126.0    55   10.5  32.5   15.6       0  1326    .350   13.06   2600
  18  2300      63.0    28   15.2  23.0   16.1       0   819    .250   12.94   1313
  19  2300      45.0    20   16.4  20.6   16.3       0   571    .150   12.82    875
  20  2300      20.0     9   17.7  17.5   16.4       0   442    .150   12.71    540
  21  2300       5.0     2   18.9  16.3   16.6       0   615    .150   12.71    330
  22   600       0.0     0   17.4   4.0   14.4       0  3632   1.870   12.71     74
  23  2300       0.0     0   24.1   4.6    9.4       0 41623    .310    5.50      9
----------------------------------------------------------------------------
           CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2  FAC.      HP  ALDE.      HC       CO     NO2
----------------------------------------------------------------------------
   1   0.0     50.4      427     2.2  .070     0.0      I       R        R       R
   2   0.0     31.7      129     7.3  .060      .1    0.0   27.71    112.9     6.4
   3   0.0     56.6      141    22.7  .060      .3    0.0   13.03     32.5     5.2
   4   0.0     63.8       91    59.8  .050      .5    0.0    6.65      9.5     6.2
   5   0.0     68.7      109    69.1  .030      .4    0.0    5.19      8.2     5.2
   6   0.0    110.5      109   270.7  .060     1.6    0.0    4.17      4.1    10.2
   7   0.0    125.3      205   441.2 0.000     0.0    0.0    3.15      5.2    11.1
   8   0.0    141.7      252   554.9  .040     1.7    0.0    3.26      5.8    12.8
   9   0.0    197.4     1734   515.8 0.000     0.0    0.0    4.06     35.6    10.6
  10   0.0    360.1    10462   168.1 0.000     0.0    0.0    6.79    147.4     3.2
  11   0.0     43.0      503     1.8  .070     0.0      I       R        R       R
  12   0.0    806.4      111      .5  .120     0.0      I       R        R       R
  13   0.0    586.3    18159   444.2  .025     2.8    0.0    5.31    164.5     4.0
  14   0.0    393.6    13153   767.2  .055     5.6    0.0    3.87    129.5     7.6
  15   0.0    162.1     6750   581.8  .035     3.2    0.0    1.79     74.5     6.4
  16   0.0     76.1     3146   539.7  .060     5.0    0.0     .92     38.0     6.5
  17   0.0    144.4      770   939.6  .060     3.3    0.0    2.62     13.9    17.0
  18   0.0     64.4      397   342.5 0.000     0.0    0.0    2.33     14.4    12.4
  19   0.0     41.0      217   208.4  .065     1.3    0.0    2.08     11.0    10.6
  20   0.0     27.2      186   110.3 0.000     0.0    0.0    3.10     21.3    12.6
  21   0.0     35.2      173    62.7 0.000     0.0    0.0   16.08     79.2    28.6
  22   0.0     44.1      459     3.0  .080     0.0      I       R        R       R
  23   0.0    870.9      131      .6  .060     0.0      I       R        R       R

CYCLE COMPOSITE      HC       9.363   GRAM/BHP HR
                     CO      71.306   GRAM/BHP HR
                     NO2      8.664   GRAM/BHP HR
                     ALDE     0.000   GRAM/BHP HR
                     BSFC      .720     LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-16-72 RUN-3 ENG.1-3 72- VERSION  6 BTDC
---------------------------------------------------------------------------
               DYNA.         MAN. FUEL     A/F             DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC      CO       CO2      NO
---------------------------------------------------------------------------
   1   600      0.0     0   17.4   3.8    15.1        0   4236  1.300     12.71      51
   2  1200      5.0     1   19.9   7.7    15.9        0   1101   .150     13.18      85
   3  1200     19.0     4   19.5   8.0    15.7        0   1690   .180     13.48     155
   4  1200     42.0    10   17.1   9.6    16.5        0   2014   .050     12.82     500
   5  1200     58.0    13   15.5  11.4    16.8        0   2081   .050     12.82     720
   6  1200    116.0    27   10.7  15.8    17.0        0   2166   .050     12.71    1700
   7  1200    174.0    40    3.7  23.1    16.5        0   1681   .070     12.94    1850
   8  1200    190.0    43    2.2  24.0    16.4        0   1793   .100     12.94    2025
   9  1200    213.0    49    1.8  26.7    14.9        0   2578  1.090     13.33    1900
  10  1200    232.0    53     .4  34.2    12.5        0   4100  5.500     11.24     590
  11   600      0.0     0   17.5   3.8    14.7        0   3770  1.520     12.94      64
  12  1200      0.0     0   22.0   4.1    17.4        0  47993   .280      6.91      12
  13  2300    252.0   110    1.3  66.2    13.9        0   3314  5.140     11.36     720
  14  2300    232.0   102    2.2  60.2    13.1        0   2292  3.930     11.84    1325
  15  2300    207.0    91    2.5  52.9    14.5        0    861  1.910     12.47    1000
  16  2300    189.0    83    2.7  50.2    15.2        0    473  1.200     12.47     900
  17  2300    126.0    55   10.5  32.5    15.5        0   1459   .390     12.82    2700
  18  2300     63.0    28   15.3  23.0    16.1        0    883   .180     12.59    1350
  19  2300     45.0    20   16.4  20.7    16.2        0    671   .180     12.59     950
  20  2300     20.0     9   18.2  17.5    16.6        0    457   .150     12.22     470
  21  2300      5.0     2   14.2  14.5    16.9        0    500   .130     11.92     265
  22   600      0.0     0   17.6   3.8    14.5        0   3561  1.770     12.34      57
  23  2300      0.0     0   24.0   4.0    18.4        0  43707   .250      5.50      16
---------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2  FAC.       HP  ALDE.      HC       CO     NO2
---------------------------------------------------------------------------
   1   0.0    50.6     314     2.0  .070      0.0      I        R        R       R
   2   0.0    28.6      79     7.3  .060       .1    0.0    25.04     68.9     6.4
   3   0.0    44.3      95    13.5  .060       .3    0.0    10.21     22.0     3.1
   4   0.0    67.1      34    55.3  .050       .5    0.0     6.99      3.5     5.8
   5   0.0    82.3      40    94.5  .030       .4    0.0     6.21      3.0     7.1
   6   0.0   119.6      56   311.7  .060      1.6    0.0     4.51      2.1    11.8
   7   0.0   133.6     112   488.4 0.000      0.0    0.0     3.36      2.8    12.3
   8   0.0   147.7     166   553.7  .040      1.7    0.0     3.40      3.8    12.8
   9   0.0   212.8    1817   520.5 0.000      0.0    0.0     4.37     37.3    10.7
  10   0.0   370.6   10050   177.2 0.000      0.0    0.0     7.00    189.6     3.3
  11   0.0    43.8     357     2.5  .070      0.0      I        R        R       R
  12   0.0   744.5      88      .6  .120      0.0      I        R        R       R
  13   0.0   591.2   18524   426.5  .025      2.8    0.0     5.36    167.9     3.9
  14   0.0   391.1   13549   750.8  .055      5.6    0.0     3.85    133.4     7.4
  15   0.0   142.8    6400   550.7  .035      3.2    0.0     1.58     70.6     6.1
  16   0.0    78.5    4024   446.0  .060      5.0    0.0      .95     48.6     6.0
  17   0.0   161.0     870   989.4  .060      3.3    0.0     2.92     15.8    17.9
  18   0.0    71.7     295   363.7 0.000      0.0    0.0     2.60     10.7    13.2
  19   0.0    49.1     266   230.7  .065      1.3    0.0     2.49     13.5    11.7
  20   0.0    29.2     194    99.8 0.000      0.0    0.0     3.34     22.1    11.4
  21   0.0    27.2     143    47.8 0.000      0.0    0.0    12.42     65.2    21.8
  22   0.0    42.4     426     2.3  .080      0.0      I        R        R       R
  23   0.0   783.6      91     1.0  .060      0.0      I        R        R       R

CYCLE COMPOSITE     HC       8.922    GRAM/BHP HR
                    CO      72.762    GRAM/BHP HR
                    NO2      8.734    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .717      LB/BHP HR
```

```
                         PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-18-72 RUN-1 ENG.1-3 72-VERSION          TDC   600 RPM
-----------------------------------------------------------------------------------------
                   DYNA.          MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED         LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2     NO
-----------------------------------------------------------------------------------------
  1   600           0.0     0   16.5    4.7   17.0         0   3054   1.450   12.71     62
  2  1200           4.0     1   19.5    7.7   17.7         0   1072    .350   13.48    106
  3  1200          16.0     4   18.8    8.6   18.1         0   1493    .390   13.33    175
  4  1200          36.0     8   16.9   10.2   18.8         0   1192    .150   13.06    295
  5  1200          50.0    11   15.6   11.0   19.2         0   1198    .150   12.82    365
  6  1200         100.0    23   10.7   14.3   19.6         0   1316    .130   12.34    825
  7  1200           0.0     0    0.0    0.0    0.0         0      0   0.000    0.00      0
  8  1200           0.0     0    0.0    0.0    0.0         0      0   0.000    0.00      0
  9  1200         184.0    42    1.9   27.6   16.4         0   1741   1.450   13.48   1188
 10  1200         200.0    46     .4   34.2   14.2         0   3235   5.780   11.01    415
 11   600           0.0     0   16.6    4.0   16.3         0   3270   2.140   12.71     61
 12  1200           0.0     0   21.6    4.5   19.1         0  33572    .490    8.48     19
 13  2300         226.0    99    1.4   66.3   14.4         0   2825   5.080   11.48    560
 14  2300         208.0    91    2.2   64.2   14.4         0   2336   5.140   11.48    675
 15  2300         185.0    81    2.4   56.1   15.6         0    864   2.520   13.06    680
 16  2300         170.0    74    2.5   53.1   16.1         0    535   1.940   12.94    595
 17  2300         113.0    49   10.4   33.4   17.7         0    613    .390   13.06   1500
 18  2300          57.0    25   14.9   23.7   18.5         0    294    .180   12.71    705
 19  2300          41.0    18   15.7   22.3   18.7         0    269    .150   12.71    545
 20  2300          18.0     8   17.2   19.4   19.0         0    151    .150   12.71    340
 21  2300           5.0     2   18.3   17.2   19.3         0    115    .150   12.59    230
 22   600           0.0     0   16.4    4.1   17.3         0   2881   1.450   12.59     71
 23  2300           0.0     0   23.7    4.6   23.3         0  36530    .310    6.05     12
-----------------------------------------------------------------------------------------
          CALCULATED GRAM/HR             WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2    FAC.       HP  ALDE.       HC       CO      NO2
-----------------------------------------------------------------------------------------
  1   0.0     45.0     432      3.0   .070       0.0     I         R        R        R
  2   0.0     26.9     177      8.8   .060        .1   0.0     29.38    193.9      9.6
  3   0.0     42.0     222     16.3   .060        .2   0.0     11.49     60.6      4.5
  4   0.0     41.4     105     34.0   .050        .4   0.0      5.03     12.8      4.1
  5   0.0     45.7     115     46.2   .030        .3   0.0      4.00     10.1      4.0
  6   0.0     67.7     135    141.0   .060       1.4   0.0      2.96      5.9      6.2
  7   0.0      0.0       0      0.0  0.000       0.0   0.0      0.00      0.0      0.0
  8   0.0      0.0       0      0.0   .040       0.0   0.0      0.00      0.0      0.0
  9   0.0    144.3    2428    326.9  0.000       0.0   0.0      3.43     57.7      7.8
 10   0.0    293.2   10584    124.9  0.000       0.0   0.0      6.42    231.6      2.7
 11   0.0     34.1     517      2.4   .070       0.0     I         R        R        R
 12   0.0    555.9     164      1.0   .120       0.0     I         R        R        R
 13   0.0    504.5   18323    332.0   .025       2.5   0.0      5.10    185.1      3.4
 14   0.0    403.7   17940    387.2   .055       5.0   0.0      4.43    197.0      4.3
 15   0.0    140.3    8268    366.7   .035       2.8   0.0      1.73    102.1      4.5
 16   0.0     86.2    6321    318.6   .060       4.5   0.0      1.16     84.9      4.3
 17   0.0     68.7     883    558.4   .060       3.0   0.0      1.39     17.9     11.3
 18   0.0     24.5     303    194.8  0.000       0.0   0.0       .98     12.1      7.8
 19   0.0     21.1     238    142.0   .065       1.2   0.0      1.17     13.2      7.9
 20   0.0     10.3     207     77.2  0.000       0.0   0.0      1.31     26.3      9.8
 21   0.0      7.0     185     46.7  0.000       0.0   0.0      3.22     84.7     21.3
 22   0.0     37.4     380      3.1   .080       0.0     I         R        R        R
 23   0.0    761.2     130       .8   .060       0.0     I         R        R        R

CYCLE COMPOSITE    HC      8.596    GRAM/BHP HR
                   CO    110.072    GRAM/BHP HR
                   NO2     5.541    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .855      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-17-72 RUN-4 ENG.1-3 72-VERSION   5 ATDC
------------------------------------------------------------------------------------------
              DYNA.          MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO   ALDE.     HC       CO       CO2      NO
------------------------------------------------------------------------------------------
  1    600     0.0     0   14.5    4.0    18.5       0   1770     .470     13.33    118
  2   1200     4.0     1   19.4    6.3    18.8       0    699     .210     13.48     85
  3   1200    15.0     3   18.2    8.8    19.1       0    782     .130     13.48    160
  4   1200    33.0     8   16.8   10.4    19.5       0    821     .100     13.33    210
  5   1200    46.0    11   15.1   11.5    19.9       0    852     .100     12.94    275
  6   1200    91.0    21   10.8   15.1    20.1       0   1096     .100     12.71    555
  7   1200     0.0     0    0.0    0.0     0.0       0      0    0.000      0.00      0
  8   1200     0.0     0    0.0    0.0     0.0       0      0    0.000      0.00      0
  9   1200     0.0     0    0.0    0.0     0.0       0      0    0.000      0.00      0
 10   1200   182.0    42     .3   34.2    14.8       0   2888    5.560     11.24    410
 11    600     1.0     0   15.0    4.2    17.7       0   2184     .930     13.63    110
 12   1200     1.0     0   20.9    4.4    18.7       0  20168     .470     10.89     29
 13   2300   198.0    87    1.3   70.1    13.2       0   2429    5.450     11.48    380
 14   2300   182.0    80    2.0   69.8    12.6       0   2698    7.430      9.93    245
 15   2300   162.0    71    2.5   57.8    14.9       0    870    2.870     12.71    585
 16   2300     0.0     0    0.0    0.0     0.0       0      0    0.000      0.00      0
 17   2300    99.0    43   10.9   32.5    17.3       0    422     .280     13.18   1125
 18   2300    50.0    22   14.5   24.6    17.8       0    198     .180     13.06    590
 19   2300    36.0    16   15.6   22.7    16.1       0    151     .150     12.71    450
 20   2300    16.0     7   16.9   20.1    20.0       0     91     .100     12.71    280
 21   2300     4.0     2   17.8   18.4    19.1       0     75     .100     12.47    200
 22    600     0.0     0   14.9    7.3    17.5       0   1858    1.010     12.59    113
 23   2300     0.0     0   23.0    6.7    23.2       0  25870     .310      6.91     14
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
------------------------------------------------------------------------------------------
  1    0.0    23.0     123     5.1  .070      0.0      I       R        R       R
  2    0.0    14.5      88     5.9  .060       .1    0.0   15.87     96.4     6.4
  3    0.0    22.8      77    15.5  .060       .2    0.0    6.66     22.3     4.5
  4    0.0    28.7      71    24.3  .050       .4    0.0    3.80      9.4     3.2
  5    0.0    33.8      80    36.3  .030       .3    0.0    3.22      7.6     3.5
  6    0.0    58.1     107    97.7  .060      1.2    0.0    2.79      5.2     4.7
  7    0.0     0.0       0     0.0 0.000      0.0    0.0    0.00      0.0     0.0
  8    0.0     0.0       0     0.0  .040      0.0    0.0    0.00      0.0     0.0
  9    0.0     0.0       0     0.0 0.000      0.0    0.0    0.00      0.0     0.0
 10    0.0   262.2   10196   123.6 0.000      0.0    0.0    6.31    245.2     3.0
 11    0.0    28.2     242     4.7  .070       .0    0.0  246.47   2119.8    41.2
 12    0.0   300.4     142     1.4  .120       .0    0.01316.97    620.0     6.3
 13    0.0   449.7   20384   233.6  .025      2.2    0.0    5.19    235.1     2.7
 14    0.0   484.6   26954   146.1  .055      4.4    0.0    6.08    338.2     1.8
 15    0.0   145.5    9702   325.0  .035      2.5    0.0    2.05    136.8     4.6
 16    0.0     0.0       0     0.0  .060      0.0    0.0    0.00      0.0     0.0
 17    0.0    46.0     618   407.8  .060      2.6    0.0    1.06     14.2     9.4
 18    0.0    16.6     306   164.8 0.000      0.0    0.0     .76     14.0     7.5
 19    0.0    12.1     242   114.5  .065      1.0    0.0     .77     15.4     7.6
 20    0.0     6.4     144    66.1 0.000      0.0    0.0     .92     20.5     9.4
 21    0.0     5.0     134    44.1 0.000      0.0    0.0    2.83     76.5    25.2
 22    0.0    44.6     490     9.0  .080      0.0      I       R        R       R
 23    0.0   801.7     194     1.4  .060      0.0      I       R        R       R

CYCLE COMPOSITE    HC      9.806    GRAM/BHP HR
                   CO    167.834    GRAM/BHP HR
                   NO2     4.605    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC    1.061      LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-17-72 RUN-3 ENG.1-3 72-VERSION  10 ATDC
-------------------------------------------------------------------------------------
              DYNA.       MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC        CO       CO2     NO
-------------------------------------------------------------------------------------
  1    600     0.0     0  12.5    3.5   18.6       0  1231     .420     12.47    135
  2   1200     3.0     1  18.8    6.5   18.6       0  1008     .210     12.82     79
  3   1200    12.0     3  17.4   10.0   19.1       0   414     .130     12.59    128
  4   1200    28.0     6  15.2   11.1   19.9       0   455     .130     12.22    185
  5   1200    39.0     9  14.9   11.8   19.9       0   440     .130     12.22    191
  6   1200    77.0    18  10.6   14.7   19.9       0   623     .130     12.09    410
  7   1200     0.0     0   0.0    0.0    0.0       0     0    0.000      0.00      0
  8   1200     0.0     0   0.0    0.0    0.0       0     0    0.000      0.00      0
  9   1200     0.0     0   0.0    0.0    0.0       0     0    0.000      0.00      0
 10   1200   154.0    35    .3   34.2   14.6       0  2394    5.610     11.01    350
 11    600     0.0     0  13.0    3.8   17.9       0  1304     .470     12.94    145
 12   1200     0.0     0  20.4    4.0   19.0       0 23752     .580      9.37     28
 13   2300   180.0    79   1.3   66.2   14.4       0  2131    5.290     11.13    380
 14   2300   166.0    73   1.8   68.7   13.5       0  2490    7.340      9.78    235
 15   2300   148.0    65   2.3   58.3   15.2       0  1030    3.520     12.09    540
 16   2300     0.0     0   0.0    0.0    0.0       0     0    0.000      0.00      0
 17   2300    90.0    39  11.0   33.1   18.0       0   409     .310     12.71    938
 18   2300    45.0    20  14.6   24.0   18.6       0   154     .150     12.59    490
 19   2300    32.0    14  15.3   22.9   18.8       0   134     .130     12.59    410
 20   2300    14.0     6  16.6   20.0   19.0       0    83     .100     12.47    265
 21   2300     4.0     2  17.7   18.4   19.3       0    72     .100     12.22    183
 22    600     0.0     0  13.0    3.8   18.2       0  1523     .580     12.34    135
 23   2300     0.0     0  23.3    4.2   20.8       0 29504     .420      7.46     21
-------------------------------------------------------------------------------------
       CALCULATED GRAM/HR          WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.     HC        CO      NO2
-------------------------------------------------------------------------------------
  1   0.0    15.0      104     5.5  .070      0.0    I        R         R        R
  2   0.0    22.6       95     5.9  .060       .0   0.0   33.04     139.0      8.6
  3   0.0    14.7       93    15.1  .060       .2   0.0    5.36      34.0      5.5
  4   0.0    18.5      107    24.9  .050       .3   0.0    2.89      16.7      3.9
  5   0.0    19.0      113    27.4  .030       .3   0.0    2.13      12.7      3.1
  6   0.0    33.8      143    73.9  .060      1.1   0.0    1.92       8.1      4.2
  7   0.0     0.0        0     0.0 0.000      0.0   0.0    0.00       0.0      0.0
  8   0.0     0.0        0     0.0  .040      0.0   0.0    0.00       0.0      0.0
  9   0.0     0.0        0     0.0 0.000      0.0   0.0    0.00       0.0      0.0
 10   0.0   220.3    10427   106.9 0.000      0.0   0.0    6.26     296.3      3.0
 11   0.0    16.6      121     6.1  .070      0.0    I        R         R        R
 12   0.0   349.7      172     1.4  .120      0.0    I        R         R        R
 13   0.0   384.7    19291   227.8  .025      2.0   0.0    4.88     244.7      2.9
 14   0.0   446.8    26601   140.0  .055      4.0   0.0    6.15     365.9      1.9
 15   0.0   173.3    11967   301.7  .035      2.3   0.0    2.67     184.6      4.7
 16   0.0     0.0        0     0.0  .060      0.0   0.0    0.00       0.0      0.0
 17   0.0    47.0      720   358.0  .060      2.4   0.0    1.19      18.3      9.1
 18   0.0    13.2      259   138.8 0.000      0.0   0.0     .67      13.1      7.0
 19   0.0    10.9      214   111.0  .065       .9   0.0     .78      15.3      7.9
 20   0.0     6.0      146    63.5 0.000      0.0   0.0     .97      23.8     10.3
 21   0.0     4.9      137    41.1 0.000      0.0   0.0    2.80      78.1     23.5
 22   0.0    20.1      154     5.9  .080      0.0    I        R         R        R
 23   0.0   519.0      149     1.2  .060      0.0    I        R         R        R
CYCLE COMPOSITE   HC      9.465   GRAM/BHP HR
                  CO    187.674   GRAM/BHP HR
                  NO2     4.635   GRAM/BHP HR
                  ALDE    0.000   GRAM/BHP HR
                  BSFC    1.143     LB/BHP HR
```

ENGINE 1-3

EFFECT OF BASIC SPARK TIMING ON EMISSIONS

GRAPHED RESULTS

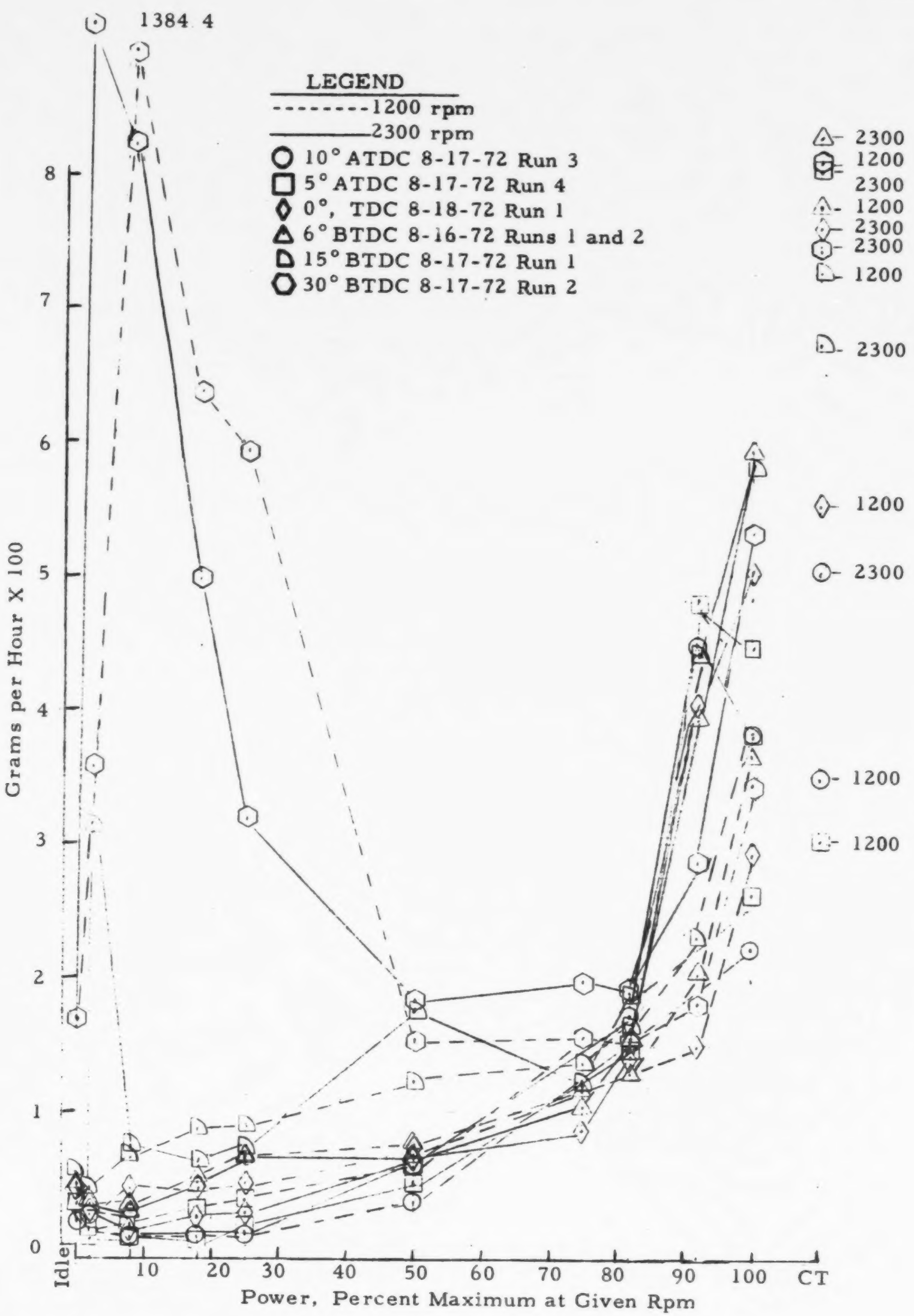


FIGURE Q-1. EFFECT OF POWER ON HC EMISSIONS RATE ENGINE 1-3, 23 MODE TEST

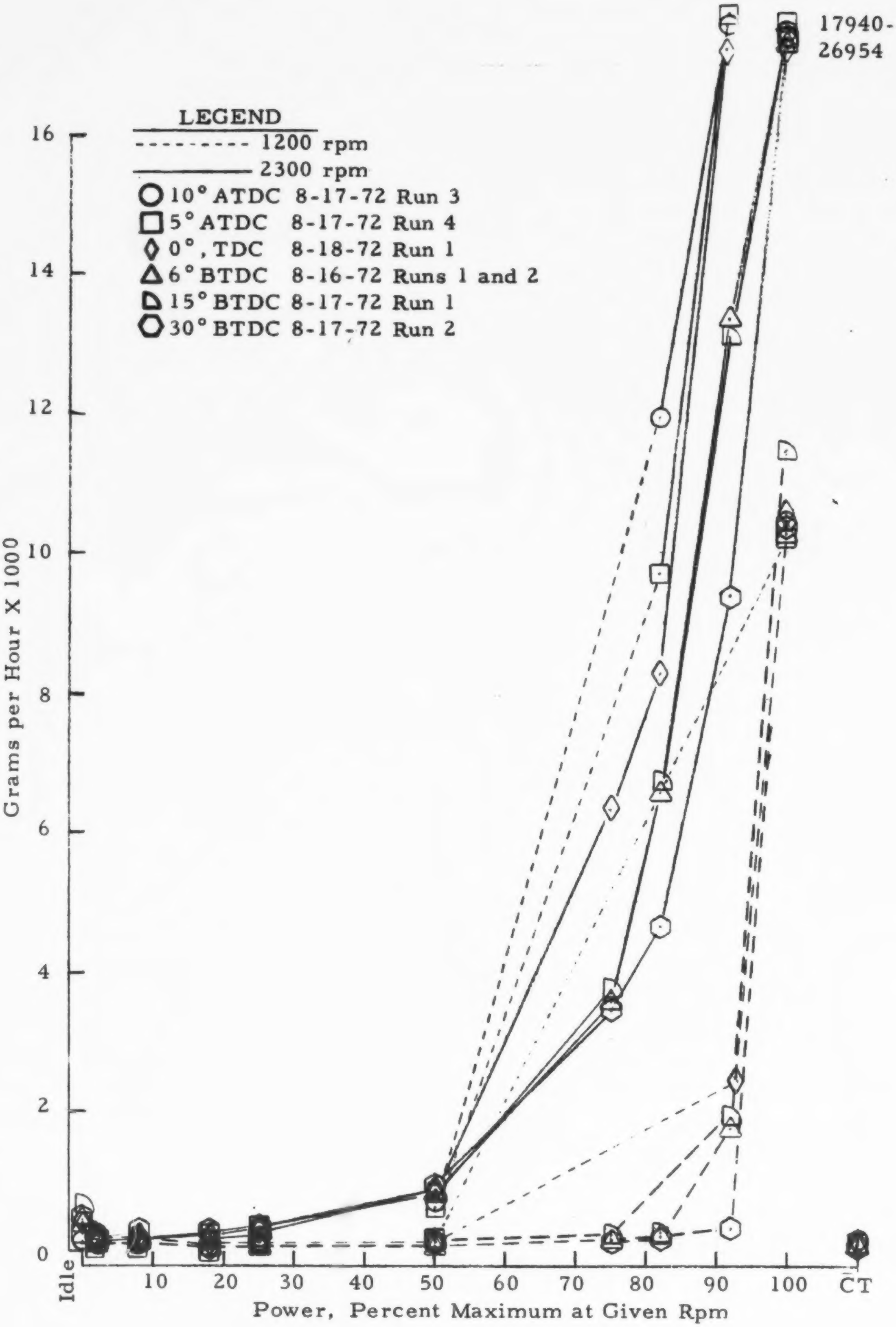


FIGURE Q-2. EFFECT OF POWER ON CO EMISSION RATE
ENGINE 1-3, 23 MODE TEST

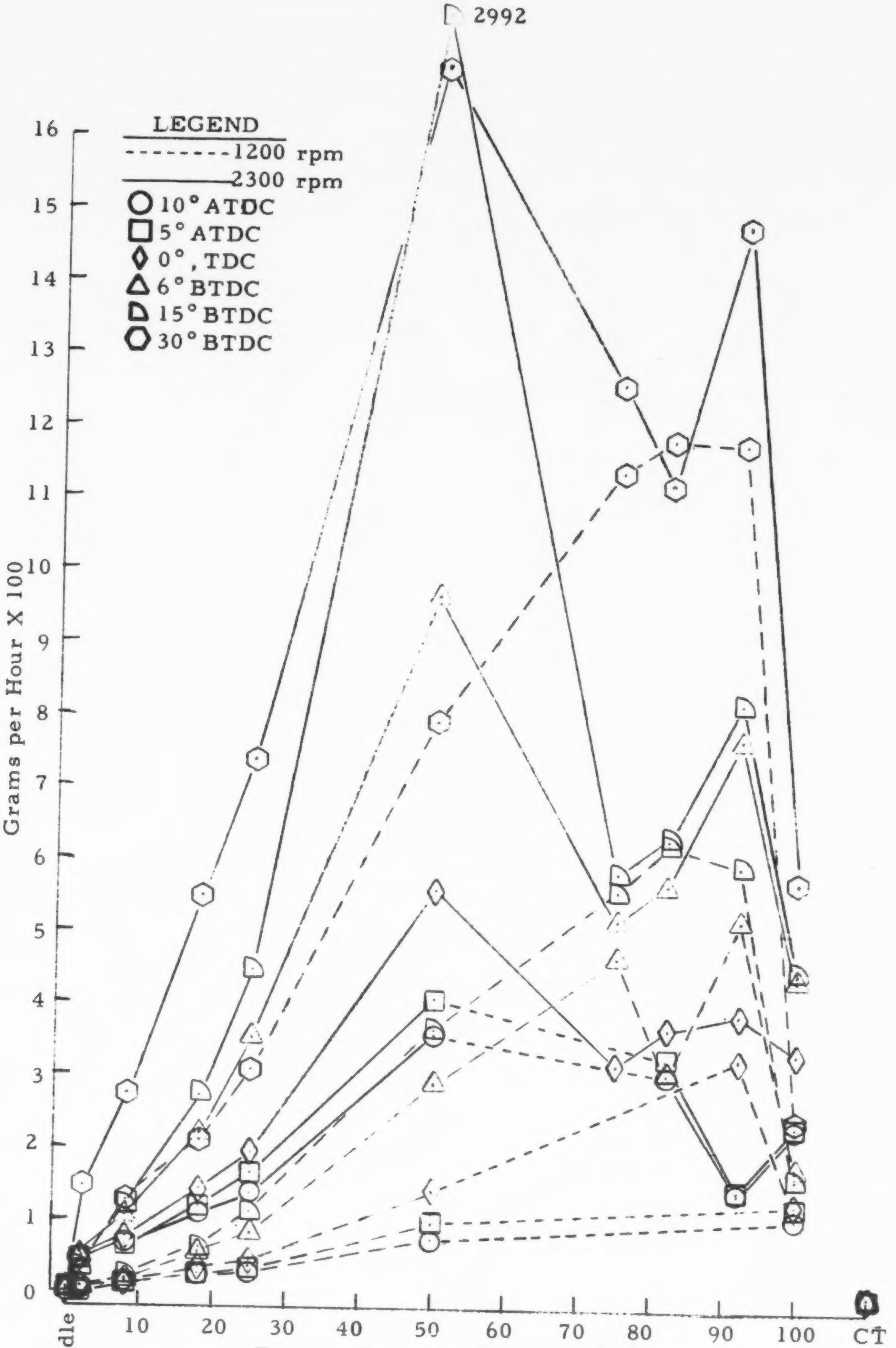


FIGURE Q-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE ENGINE 1-3, 23 MODE TEST

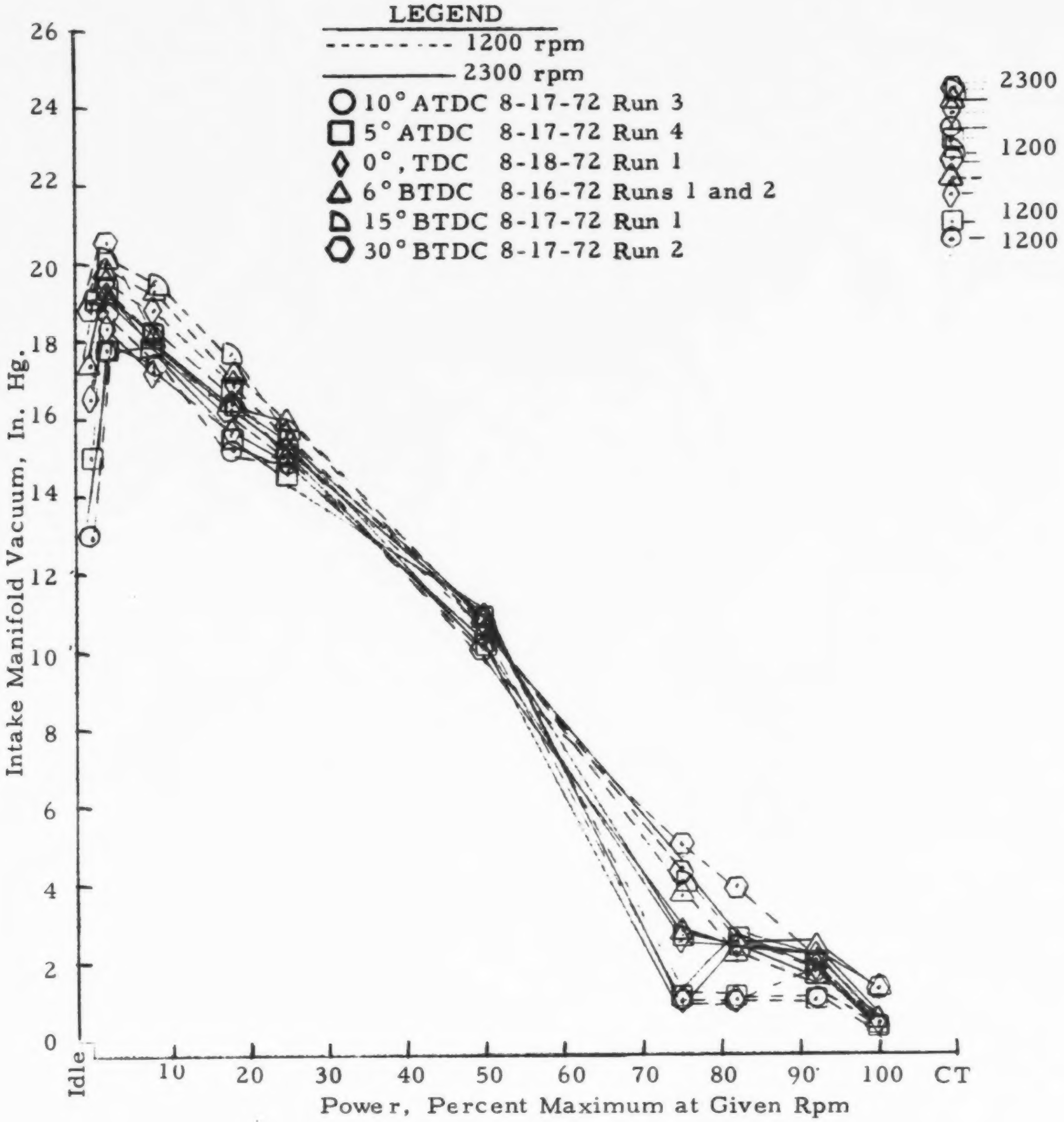


FIGURE Q-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

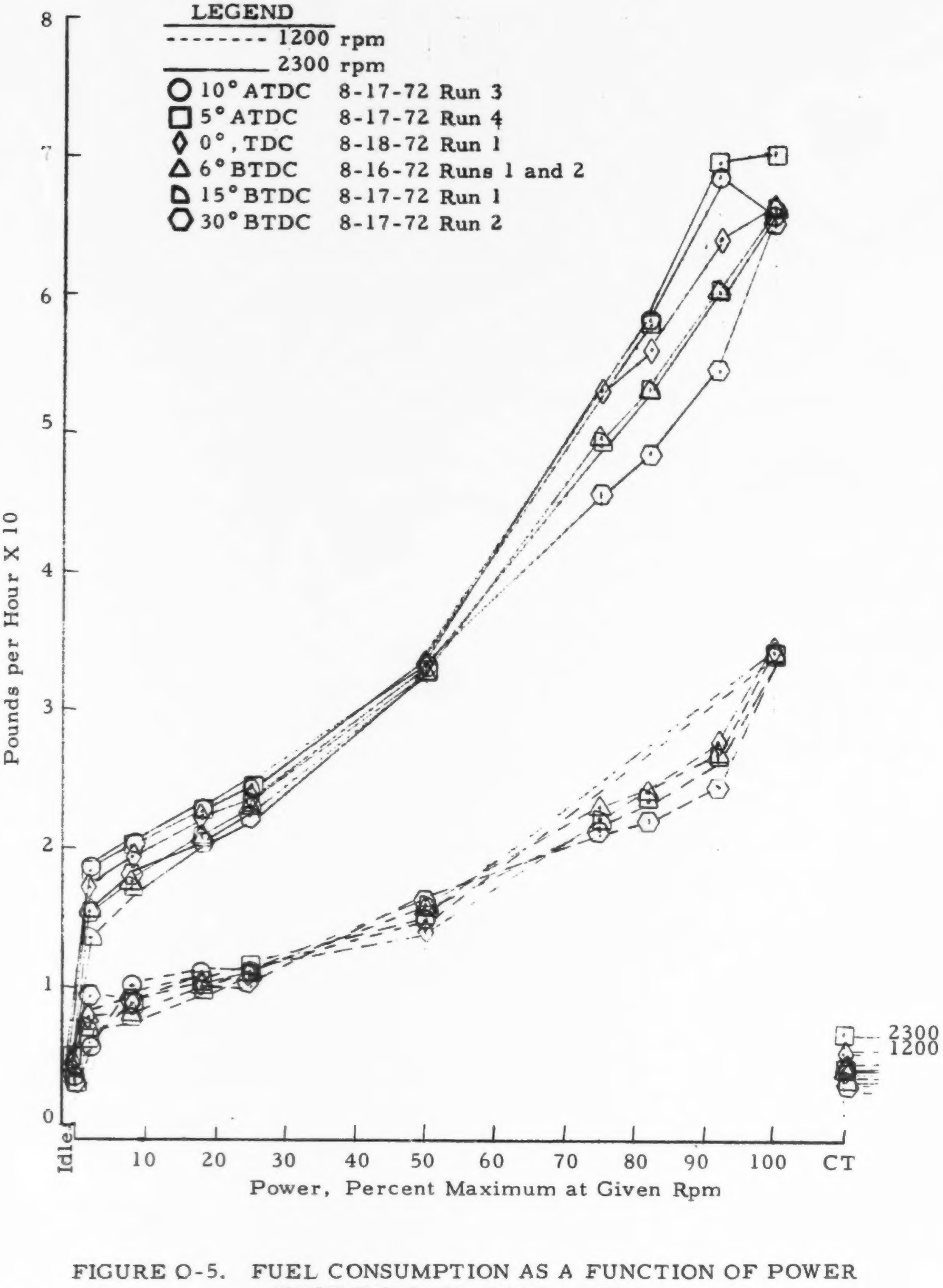


FIGURE O-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

354

APPENDIX R

ENGINE 1-3

EFFECT OF AIR-FUEL RATIO ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 1- 3

EFFECT OF AIR-FUEL RATIO ON EMISSIONS

TABULAR DATA

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
8-18-72 RUN-3 ENG.1-3 72 VERSION STD TIMING 0.060 JETS
-------------------------------------------------------------------------------
              DYNA.          MAN. FUEL    A/F                DRY CONCENTRATION
ODE SPEED     LOAD    HP   VAC. LB/HR  RATIO    ALDE.    HC       CO      CO2     NO
-------------------------------------------------------------------------------
 1    600      0.0     0   17.8    4.7   16.0          0  3257   1.550   12.82    66
 2   1200      4.0     1   19.9    7.4   16.0          0  1060    .310   13.48   110
 3   1200     18.0     4   18.9    7.9   15.8          0  1692    .350   13.48   280
 4   1200     40.0     9   17.6   10.6   16.0          0  1692    .180   13.63   530
 5   1200     55.0    13   16.2   11.3   16.2          0  1780    .180   13.48   850
 6   1200    110.0    25   12.5   15.1   15.9          0  2286    .310   13.63  2075
 7   1200    165.0    38    8.1   20.7   15.3          0  2380    .640   13.77  2500
 8   1200    180.0    41    6.5   22.5   15.0          0  2385    .770   13.91  2225
 9   1200    202.0    46    3.2   26.7   14.7          0  2396   1.480   13.77  1688
10   1200    220.0    50     .4   37.1   11.6          0  3957   8.220    9.50   250
11    600      0.0     0   17.7    4.3   14.7          0  3391   2.280   12.82    64
12   1200      0.0     0   21.9    4.3   17.5          0 42745    .420    7.00    12
13   2300    244.0   107    1.3   72.4   11.5          0  3095   7.620    9.37   290
14   2300    224.0    98   23.0   68.5   11.6          0  3177   7.430    9.37   440
15   2300    200.0    88    3.3   55.2   13.6          0  1259   3.150   12.47  1100
16   2300    183.0    80    5.0   50.8   13.6          0  1350   3.100   12.47  1075
17   2300    122.0    53   11.4   35.9   13.5          0  2455   3.010   12.34  1450
18   2300     61.0    27   15.9   24.6   14.2          0  2016   1.940   12.71  1050
19   2300     44.0    19   17.1   21.3   14.4          0  1680   1.660   12.94   830
20   2300     20.0     9   18.7   17.7   14.9          0  1177   1.200   13.06   450
21   2300      5.0     2   20.3   13.1   15.5          0  1794    .390   12.71   160
22    600      0.0     0   17.7    4.3   14.7          0  2969   2.080   12.09    66
23   2300      0.0     0   23.8    5.0   19.0          0 33847    .280    5.96    11
-------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2   FAC.      HP  ALDE.       HC       CO     NO2
-------------------------------------------------------------------------------
 1    0.0    47.3     454     3.2   .070     0.0      I        R        R       R
 2    0.0    25.6     151     8.8   .060      .1    0.0    28.01    165.5     9.7
 3    0.0    43.3     181    23.8   .060      .2    0.0    10.53     44.0     5.8
 4    0.0    58.2     125    60.5   .050      .5    0.0     6.37     13.7     6.6
 5    0.0    65.9     135   104.5   .030      .4    0.0     5.25     10.7     8.3
 6    0.0   110.5     303   333.0   .060     1.5    0.0     4.40     12.0    13.3
 7    0.0   152.6     829   532.0 0.000     0.0    0.0     4.05     22.0    14.1
 8    0.0   163.2    1064   505.4   .040     1.6    0.0     3.97     25.9    12.3
 9    0.0   187.4    2338   438.2 0.000     0.0    0.0     4.06     50.6     9.5
10    0.0   367.6   15425    77.1 0.000     0.0    0.0     7.31    306.9     1.5
11    0.0    42.8     582     2.7   .070     0.0      I        R        R       R
12    0.0   712.9     142      .7   .120     0.0      I        R        R       R
13    0.0   587.6   29220   182.8   .025     2.7    0.0     5.50    273.5     1.7
14    0.0   576.7   27243   265.2   .055     5.4    0.0     5.88    277.7     2.7
15    0.0   200.2   10118   580.7   .035     3.1    0.0     2.29    115.5     6.6
16    0.0   198.1    9188   523.7   .060     4.8    0.0     2.47    114.6     6.5
17    0.0   256.4    6349   502.7   .060     3.2    0.0     4.80    118.8     9.4
18    0.0   151.4    2944   261.9 0.000     0.0    0.0     5.67    110.2     9.8
19    0.0   109.9    2194   180.3   .065     1.3    0.0     5.70    113.9     9.4
20    0.0    65.7    1354    83.4 0.000     0.0    0.0     7.51    154.5     9.5
21    0.0    80.3     353    23.8 0.000     0.0    0.0    36.66    161.0    10.9
22    0.0    40.0     566     3.0   .080     0.0      I        R        R       R
23    0.0   797.6     133      .9   .060     0.0      I        R        R       R

CYCLE COMPOSITE     HC     10.245    GRAM/BHP HR
                    CO    157.634    GRAM/BHP HR
                    NO2     6.557    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .789      LB/BHP HR
```

```
                   PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-21-72 RUN-1 ENG.1-3 72 VERSION 6 BTDC  0.065 JETS
-------------------------------------------------------------------------------
               DYNA.        MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED     LOAD    HP  VAC. LB/HR  RATIO    ALDE.     HC        CO       CO2      NO
-------------------------------------------------------------------------------
  1    600      0.0     0  18.9    4.5   14.6        0   4983   3.190    11.13      44
  2   1200      4.0     1  20.2    6.6   15.2        0   2147   1.120    12.94      87
  3   1200     16.0     4  19.5    8.3   15.5        0   2195    .520    13.06     178
  4   1200     36.0     8  18.3    9.4   15.8        0   2274    .350    12.94     430
  5   1200     49.0    11  17.6   10.1   15.5        0   2477    .440    13.18     625
  6   1200     99.0    23  14.0   16.4   13.4        0   3572   3.750    11.72     595
  7   1200    148.0    34  10.3   22.3   12.8        0   3901   4.930    11.01     470
  8   1200    162.0    37   8.8   24.0   12.7        0   4048   5.140    10.89     410
  9   1200    182.0    42   7.1   26.6   12.5        0   4132   5.560    10.43     330
 10   1200    198.0    45    .3   43.2   10.4        0   7181  10.560     7.56      95
 11    600      0.0     0  18.6    4.2   13.7        0   5303   4.300    10.89      46
 12   1200      0.0     0  22.5    4.3   18.2        0  54019    .440     5.96       9
 13   2300      0.0     0   0.0    0.0    0.0        0      0   0.000     0.00       0
 14   2300      0.0     0   0.0    0.0    0.0        0      0   0.000     0.00       0
 15   2300    189.0    83   6.1   59.5   11.4        0   4134   8.010     9.78     380
 16   2300    172.0    75   7.9   53.6   11.3        0   4154   8.740     9.64     360
 17   2300    115.0    50  12.3   41.5   11.3        0   4259   8.530     9.50     265
 18   2300     57.0    25  16.4   29.0   11.9        0   3803   7.180    10.25     195
 19   2300     41.0    18  17.8   25.2   12.3        0   3529   6.190    10.78     180
 20   2300     18.0     8  19.4   19.4   12.9        0   3051   4.880    11.48     171
 21   2300      5.0     2  20.6   15.9   13.6        0   3153   3.520    12.34     131
 22    600      0.0     0  18.4    4.1   14.1        0   4290   3.660    11.92      50
 23   2300      0.0     0  24.1    4.3   19.5        0  33856    .310     5.96      11
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC       CO      NO2
-------------------------------------------------------------------------------
  1    0.0   68.6      888     2.0  .070     0.0      I       R        R        R
  2    0.0   45.0      474     6.1  .060      .1    0.0   49.27    519.2      6.6
  3    0.0   59.9      287    16.1  .060      .2    0.0   16.38     78.4      4.4
  4    0.0   71.7      223    45.0  .050      .4    0.0    8.72     27.1      5.5
  5    0.0   81.8      294    68.6  .030      .3    0.0    7.31     26.2      6.1
  6    0.0  167.9     3560    92.8  .060     1.4    0.0    7.42    157.4      4.1
  7    0.0  241.7     6169    96.7 0.000     0.0    0.0    7.15    182.4      2.9
  8    0.0  268.1     6878    90.2  .040     1.5    0.0    7.24    185.8      2.4
  9    0.0  304.0     8261    80.6 0.000     0.0    0.0    7.31    198.7      1.9
 10    0.0  747.0    22189    32.8 0.000     0.0    0.0   16.51    490.5       .7
 11    0.0   64.3     1053     1.9  .070     0.0      I       R        R        R
 12    0.0  892.8      147      .5  .120     0.0      I       R        R        R
 13    0.0    0.0        0     0.0  .025     0.0    0.0    0.00      0.0      0.0
 14    0.0    0.0        0     0.0  .055     0.0    0.0    0.00      0.0      0.0
 15    0.0  613.0    23989   187.1  .035     2.9    0.0    7.41    289.8      2.3
 16    0.0  537.3    22838   154.6  .060     4.5    0.0    7.13    303.2      2.1
 17    0.0  434.4    17575    89.7  .060     3.0    0.0    8.63    349.0      1.8
 18    0.0  280.9    10712    47.8 0.000     0.0    0.0   11.25    429.1      1.9
 19    0.0  232.9     8251    39.4  .065     1.2    0.0   12.97    459.5      2.2
 20    0.0  161.1     5205    30.0 0.000     0.0    0.0   20.44    660.3      3.8
 21    0.0  140.6     3170    19.4 0.000     0.0    0.0   64.21   1447.9      8.9
 22    0.0   49.8      859     1.9  .080     0.0      I       R        R        R
 23    0.0  683.9      126      .7  .060     0.0      I       R        R        R

CYCLE COMPOSITE      HC      18.719    GRAM/BHP HR
                     CO     296.476    GRAM/BHP HR
                     NO2      2.529    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .954      LB/BHP HR
```

```
                PROJECT 11-2877-01  CONTROL TECHNOLOGY
 8-18-72 RUN-2 ENG.1-3 72-VERSION   CARB.JETS 0.051
---------------------------------------------------------------------------------
             DYNA.       MAN. FUEL    A/F               DRY CONCENTRATION
ODE SPEED    LOAD   HP  VAC. LB/HR  RATIO   ALDE.     HC      CO       CO2     NO
---------------------------------------------------------------------------------
  1   600     0.0    0  17.5   4.0   16.5       0   3247  1.270     12.71     86
  2  1200     5.0    1  19.3   6.3   18.7       0   1564   .210     12.47     69
  3  1200    18.0    4  18.6   8.1   19.1       0   1380   .150     12.09    260
  4  1200    41.0    9  16.5  10.0   19.8       0   1332   .130     11.72    345
  5  1200    57.0   13  14.6  11.6   20.4       0   1459   .130     11.24    380
  6  1200     0.0    0   0.0   0.0    0.0       0      0  0.000      0.00      0
  7  1200   170.0   39   2.0  24.7   18.8       0   7747   .180     11.36   1737
  8  1200   185.0   42   1.9  25.4   18.0       0   5125   .250     12.09   2075
  9  1200   208.0   48   1.6  27.3   16.7       0   4549   .850     12.47   2050
 10  1200   226.0   52    .4  30.3   15.4       0   2812  2.780     11.92   1250
 11   600     0.0    0  17.6   3.9   16.4       0   3076  1.590     12.34     66
 12  1200     0.0    0  22.2   3.9   20.1       0  41187   .420      6.38   1412
 13  2300   240.0  105   1.3  60.1   16.1       0   2112  2.250     13.06   1687
 14  2300   221.0   97   2.2  55.2   16.3       0   1288  2.020     13.06   1512
 15  2300   197.0   86   2.3  52.4   18.1       0    770  1.300     12.94   1375
 16  2300   180.0   79   2.5  48.1   19.0       0    294   .470     12.82   1275
 17  2300   120.0   53   2.6  43.3   20.7       0    954   .210     11.60   1212
 18  2300    60.0   26  11.6  25.5   22.1       0    220   .150     10.78    300
 19  2300    43.0   19  12.9  23.0   22.3       0    303   .150     10.78    250
 20  2300    19.0    8  14.8  20.4   22.7       0    742   .150     10.55    145
 21  2300     5.0    2  15.9  18.5   23.0       0   3281   .180      9.93     97
 22   600     0.0    0  17.4   4.1   17.6       0   2407  1.230     12.71     71
 23  2300     0.0    0  23.8   4.1   24.9       0  34985   .250      5.39     11
---------------------------------------------------------------------------------
        CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC     CO    NO2  FAC.       HP  ALDE.      HC      CO     NO2
---------------------------------------------------------------------------------
  1   0.0    41.2    325    3.6  .070      0.0      I       R       R       R
  2   0.0    34.8     94    5.1  .060       .1    0.0   30.48    82.7     4.5
  3   0.0    41.0     90   25.6  .060       .2    0.0    9.96    21.9     6.2
  4   0.0    50.4     99   43.4  .050       .5    0.0    5.38    10.6     4.6
  5   0.0    66.7    120   57.6  .030       .4    0.0    5.12     9.2     4.4
  6   0.0     0.0      0    0.0  .060      0.0    0.0    0.00     0.0     0.0
  7   0.0   704.8    331  524.7 0.000      0.0    0.0   18.15     8.5    13.5
  8   0.0   459.4    453  617.6  .040      1.7    0.0   10.87    10.7    14.6
  9   0.0   408.9   1544  611.8 0.000      0.0    0.0    8.60    32.5    12.9
 10   0.0   257.9   5152  380.7 0.000      0.0    0.0    5.00    99.8     7.4
 11   0.0    38.2    399    2.7  .070      0.0      I       R       R       R
 12   0.0   667.3    137   76.0  .120      0.0      I       R       R       R
 13   0.0   370.9   7983  983.7  .025      2.6    0.0    3.53    76.0     9.4
 14   0.0   212.0   6718  826.4  .055      5.3    0.0    2.19    69.4     8.5
 15   0.0   127.8   4360  757.9  .035      3.0    0.0    1.48    50.5     8.8
 16   0.0    48.2   1555  693.4  .060      4.7    0.0     .61    19.7     8.8
 17   0.0   157.4    700  663.8  .060      3.2    0.0    2.99    13.3    12.6
 18   0.0    23.3    320  105.2 0.000      0.0    0.0     .89    12.2     4.0
 19   0.0    28.8    288   79.0  .065      1.2    0.0    1.53    15.3     4.2
 20   0.0    63.7    260   41.3 0.000      0.0    0.0    7.66    31.3     5.0
 21   0.0   263.7    292   25.9 0.000      0.0    0.0  120.45   133.5    11.8
 22   0.0    38.0    325    3.1  .080      0.0      I       R       R       R
 23   0.0   712.0    103     .8  .060      0.0      I       R       R       R

CYCLE COMPOSITE   HC      8.650   GRAM/BHP HR
                  CO     44.145   GRAM/BHP HR
                  NO2     9.739   GRAM/BHP HR
                  ALDE    0.000   GRAM/BHP HR
                  BSFC     .770     LB/BHP HR
```

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-18-72 RUN-1 ENG.1-3 72 VERSION STD TIMING 0.056 STD JETS
--------------------------------------------------------------------------------
              DYNA.       MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO    ALDE.     HC      CO      CO2    NO
--------------------------------------------------------------------------------
  1   600      0.0     0  17.4   4.1   16.2        0   4015  1.450   12.71    51
  2  1200      5.0     1  19.9   7.8   16.5        0   1170   .200   13.33    86
  3  1200     19.0     4  19.3   8.2   16.4        0   1857   .220   13.33   200
  4  1200     42.0    10  17.0  10.0   17.1        0   1928   .090   13.00   510
  5  1200     58.0    13  15.9  11.0   17.5        0   1999   .100   12.88   650
  6  1200    116.0    27  10.7  15.7   18.0        0   2108   .080   12.77  1607
  7  1200    174.0    40   3.7  23.0   17.4        0   1642   .100   12.94  1775
  8  1200    190.0    43   2.2  24.3   16.7        0   1749   .130   13.00  2019
  9  1200    213.0    49   1.8  26.8   15.4        0   2496  1.070   13.48  1900
 10  1200    232.0    53    .4  34.2   13.0        0   4060  5.640   11.19   578
 11   600      0.0     0  17.4   3.7   15.3        0   3994  1.980   12.83    59
 12  1200      0.0     0  22.0   4.1   18.6        0  49764   .320    6.65    11
 13  2300    252.0   110   1.3  66.3   13.0        0   3334  5.140   11.54   743
 14  2300    232.0   102   2.3  60.2   13.7        0   2349  3.960   12.16  1369
 15  2300    207.0    91   2.5  53.2   15.0        0    928  1.980   12.59  1038
 16  2300    189.0    83   2.8  49.8   15.8        0    474  1.090   12.71   957
 17  2300    126.0    55  10.5  32.5   16.5        0   1393   .370   12.94  2650
 18  2300     63.0    28  15.3  23.0   17.2        0    851   .220   12.77  1332
 19  2300     45.0    20  16.4  20.7   17.6        0    621   .170   12.71   913
 20  2300     20.0     9  18.0  17.5   18.0        0    450   .150   12.47   505
 21  2300      5.0     2  19.1  15.4   18.5        0    558   .140   12.32   298
 22   600      0.0     0  17.5   3.9   16.0        0   3596  1.820   12.53    66
 23  2300      0.0     0  24.1   4.3   21.6        0  42665   .280    5.50    13
--------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.      HC      CO     NO2
--------------------------------------------------------------------------------
  1   0.0    51.3     374     2.2  .070      0.0      I       R       R       R
  2   0.0    30.3     105     7.4  .060       .1    0.0   26.56    91.7     6.5
  3   0.0    50.3     120    18.0  .060       .3    0.0   11.58    27.7     4.1
  4   0.0    65.8      62    57.8  .050       .5    0.0    6.86     6.5     6.0
  5   0.0    75.7      76    81.7  .030       .4    0.0    5.71     5.8     6.2
  6   0.0   114.9      88   290.9  .060      1.6    0.0    4.34     3.3    11.0
  7   0.0   129.7     160   465.6 0.000      0.0    0.0    3.26     4.0    11.7
  8   0.0   144.9     218   555.3  .040      1.7    0.0    3.34     5.0    12.8
  9   0.0   205.0    1775   518.1 0.000      0.0    0.0    4.21    36.5    10.6
 10   0.0   365.4   10254   172.7 0.000      0.0    0.0    6.89   193.4     3.3
 11   0.0    44.1     441     2.2  .070      0.0      I       R       R       R
 12   0.0   774.7     101      .6  .120      0.0      I       R       R       R
 13   0.0   589.3   18353   436.0  .025      2.8    0.0    5.34   166.3     4.0
 14   0.0   392.2   13356   758.9  .055      5.6    0.0    3.86   131.5     7.5
 15   0.0   152.8    6582   567.2  .035      3.2    0.0    1.69    72.6     6.3
 16   0.0    77.3    3592   518.3  .060      5.0    0.0     .93    43.4     6.3
 17   0.0   152.7     819   964.4  .060      3.3    0.0    2.77    14.8    17.5
 18   0.0    67.9     355   352.9 0.000      0.0    0.0    2.46    12.9    12.8
 19   0.0    45.1     249   219.9  .065      1.3    0.0    2.29    12.6    11.2
 20   0.0    28.2     190   105.1 0.000      0.0    0.0    3.22    21.7    12.0
 21   0.0    31.1     158    55.2 0.000      0.0    0.0   14.21    72.1    25.2
 22   0.0    43.3     442     2.6  .080      0.0      I       R       R       R
 23   0.0   828.3     110      .8  .060      0.0      I       R       R       R

CYCLE COMPOSITE    HC      9.147    GRAM/BHP HR
                   CO     72.183    GRAM/BHP HR
                   NO2     8.704    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .719      LB/BHP HR
```

ENGINE 1-3

EFFECT OF AIR-FUEL RATIO ON EMISSIONS

GRAPHED RESULTS

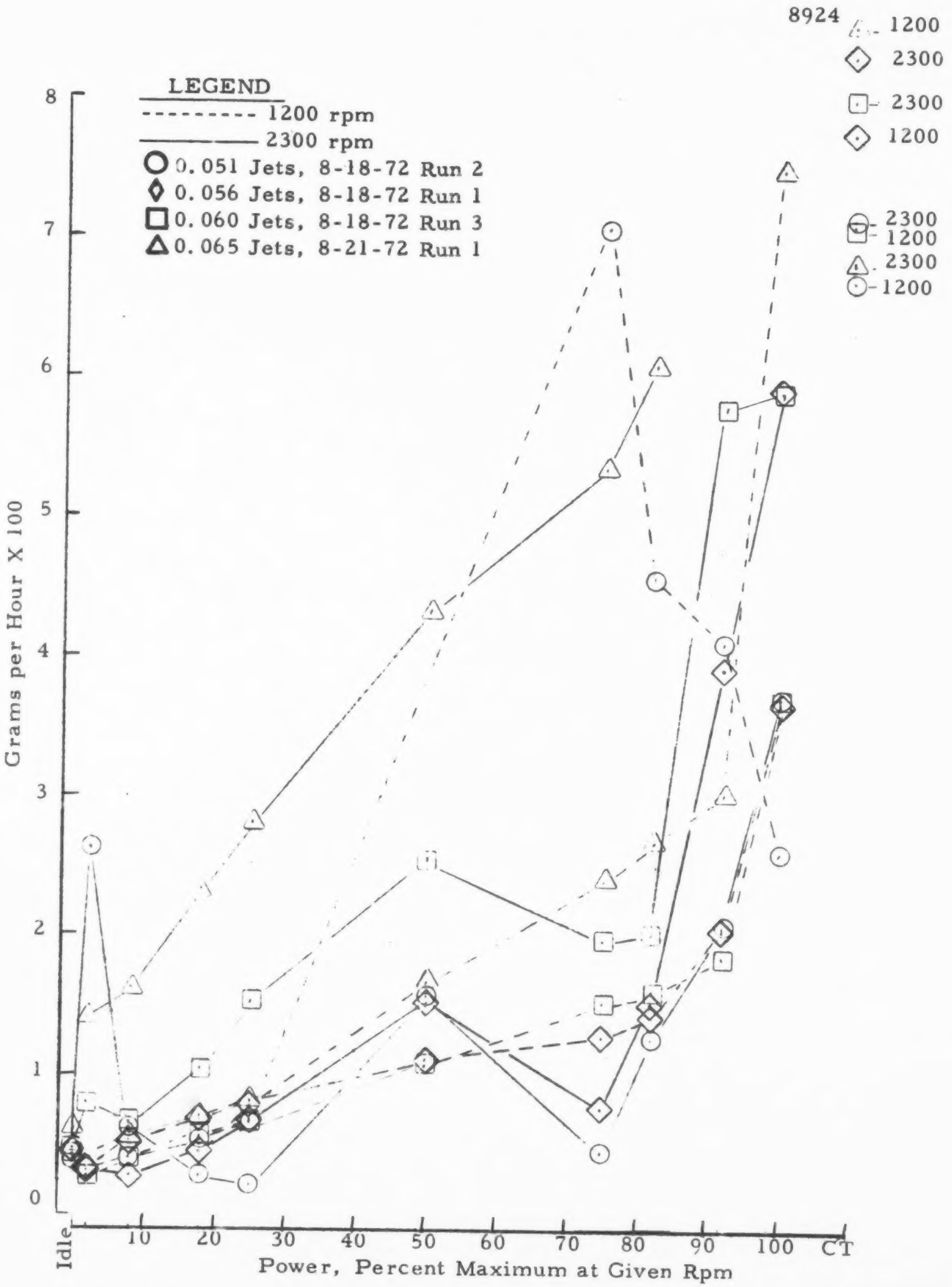


FIGURE R-1. EFFECT OF POWER ON HC EMISSION RATE
ENGINE 1-3, 23 MODE TEST

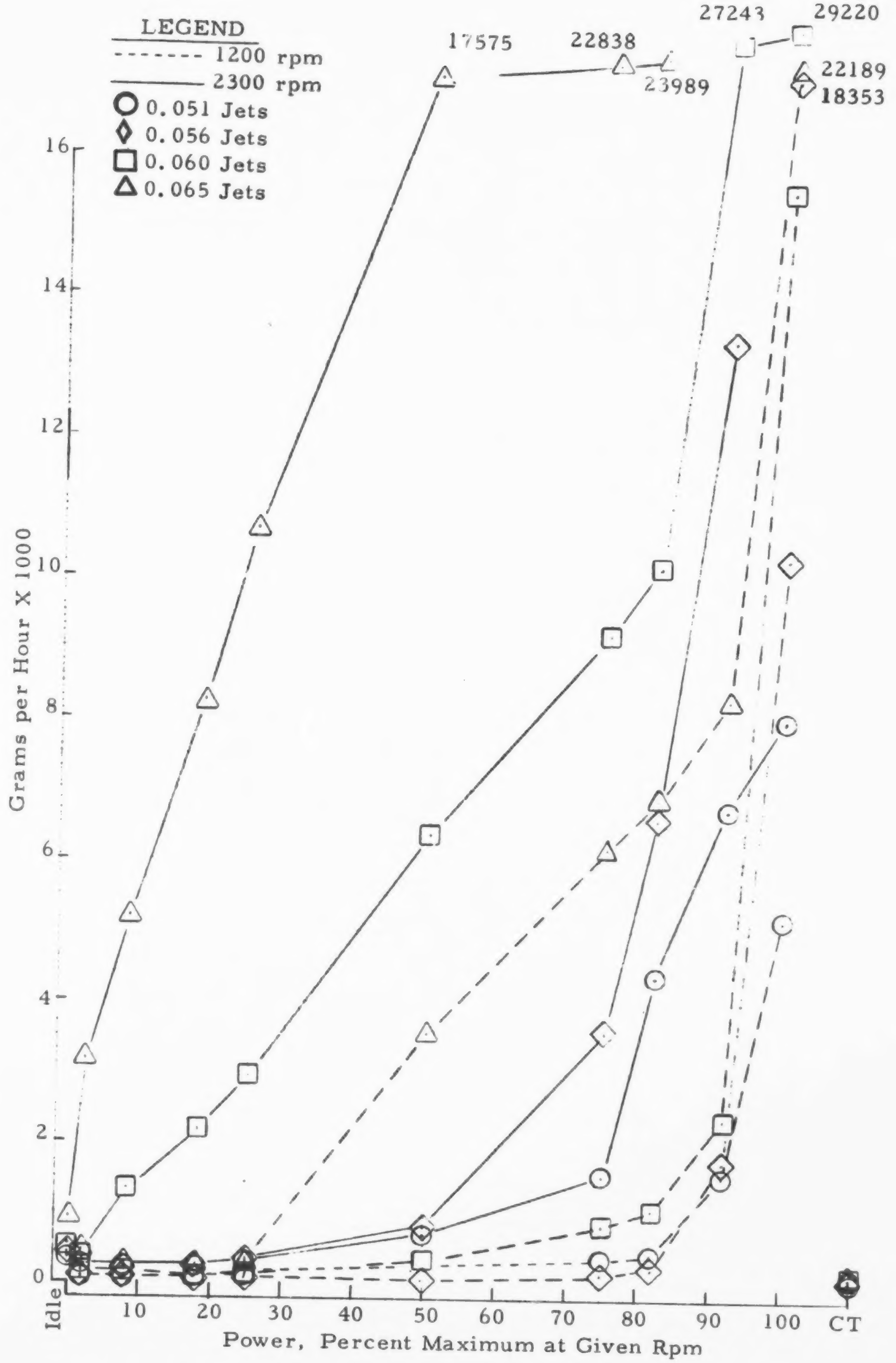


FIGURE R-2. EFFECT OF POWER ON CO EMISSION RATE
ENGINE 1-3, 23 MODE TEST

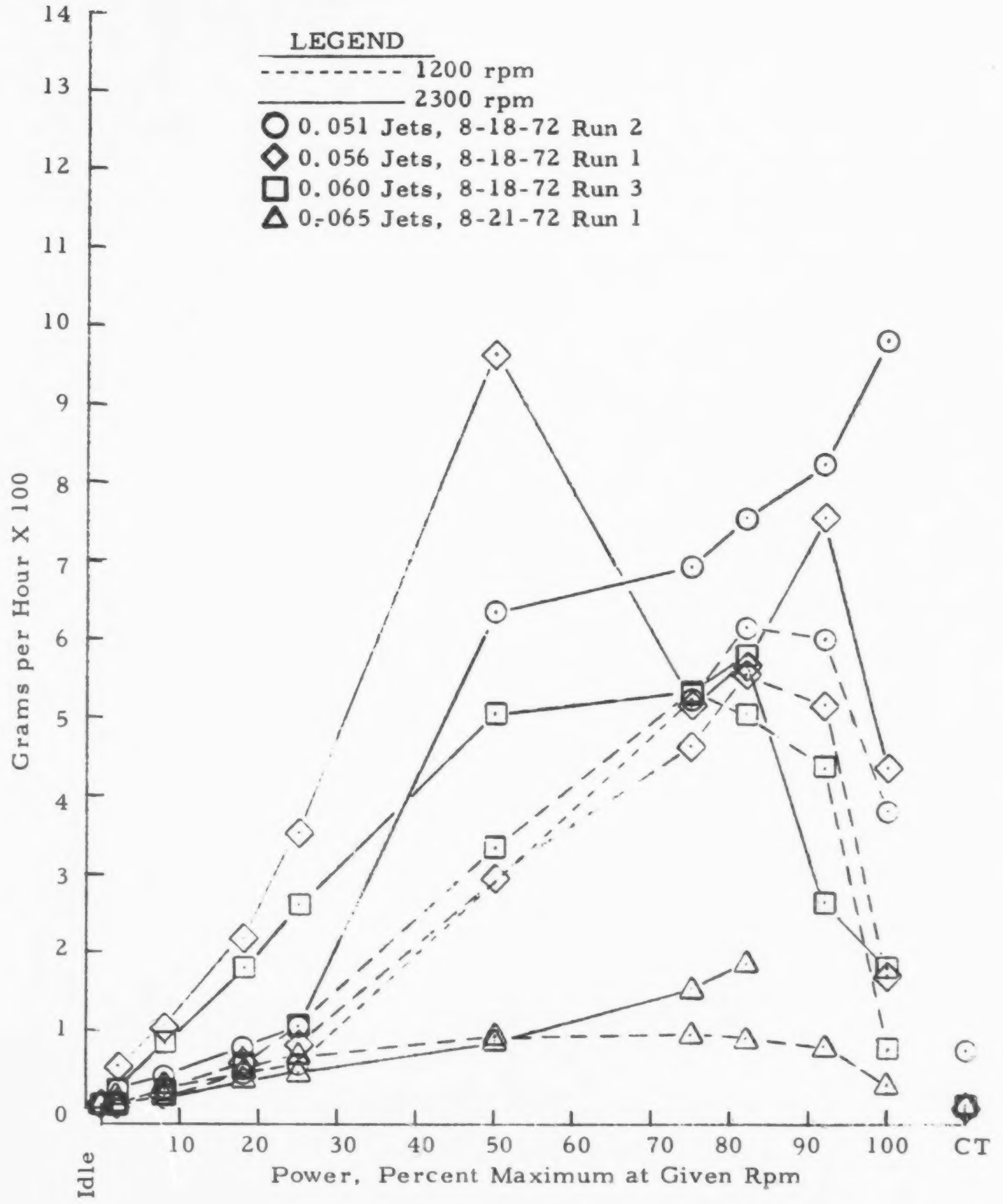


FIGURE R-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE ENGINE 1-3, 23 MODE TEST

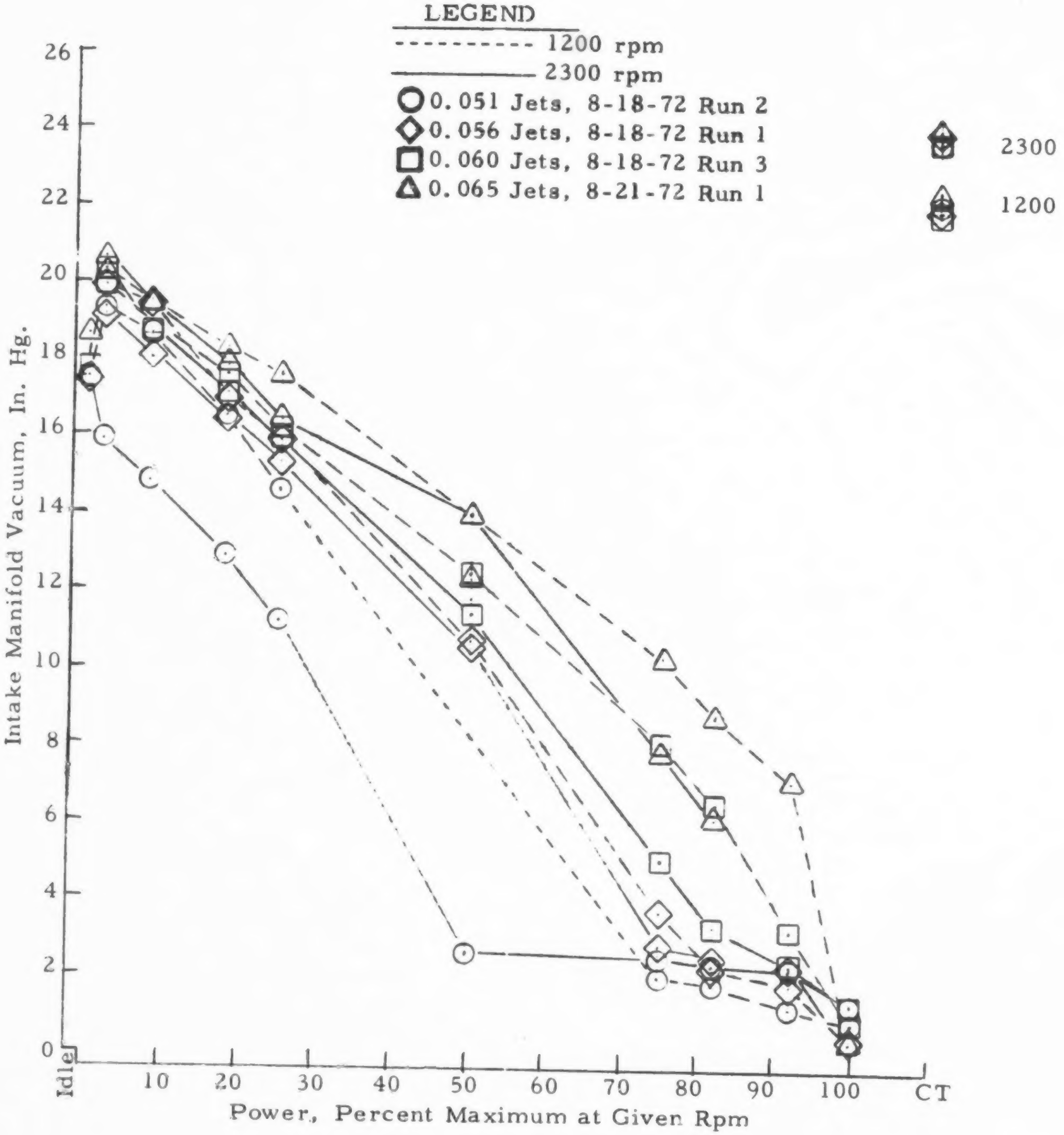


FIGURE R-4. MANIFOLD VACUUM AS A FUNCTION OF POWER
ENGINE 1-3, 23 MODE TEST

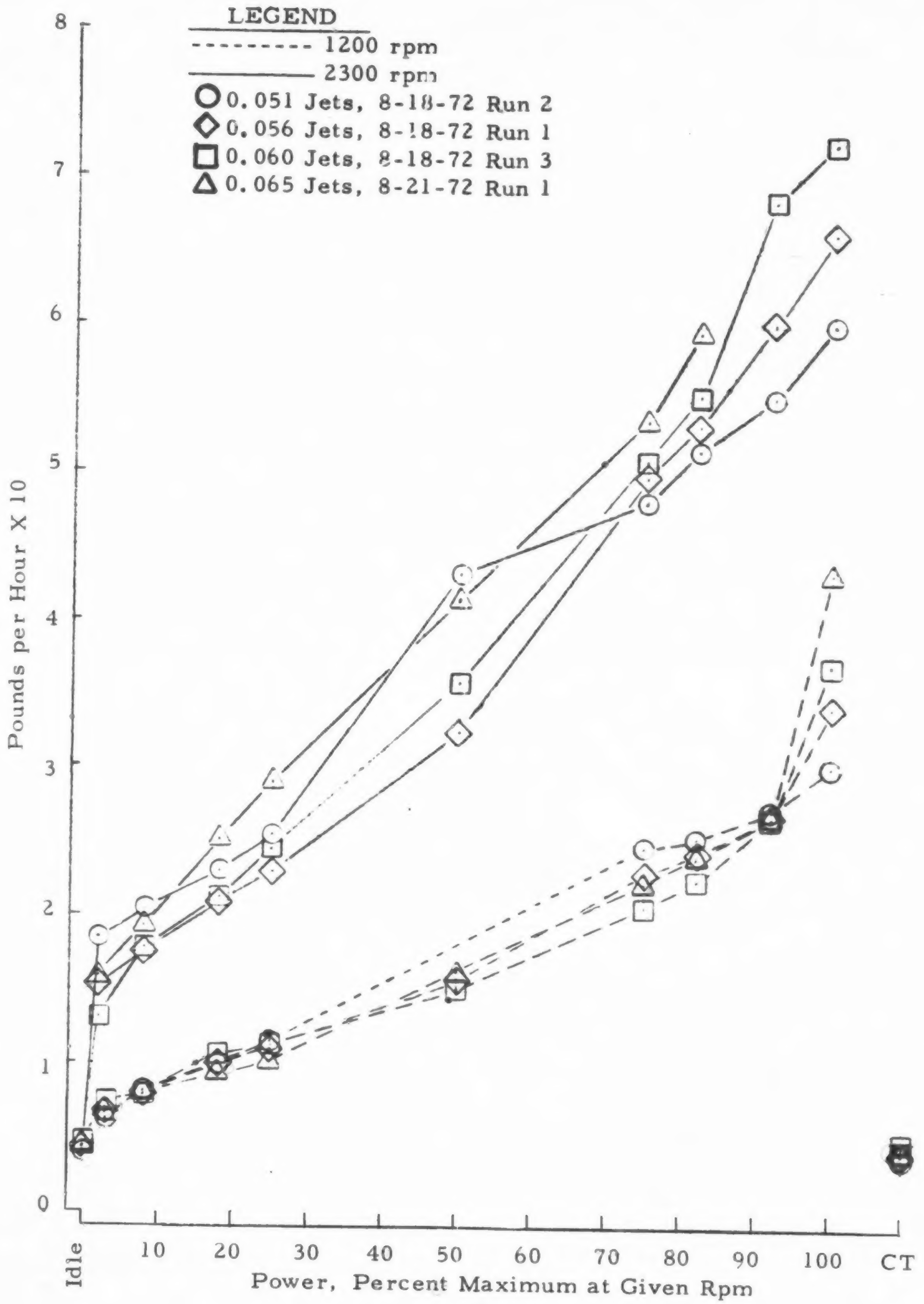


FIGURE R-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

APPENDIX S

ENGINE 1-3

EFFECT OF LABORATORY EGR ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 1-3

EFFECT OF LABORATORY EGR ON EMISSIONS

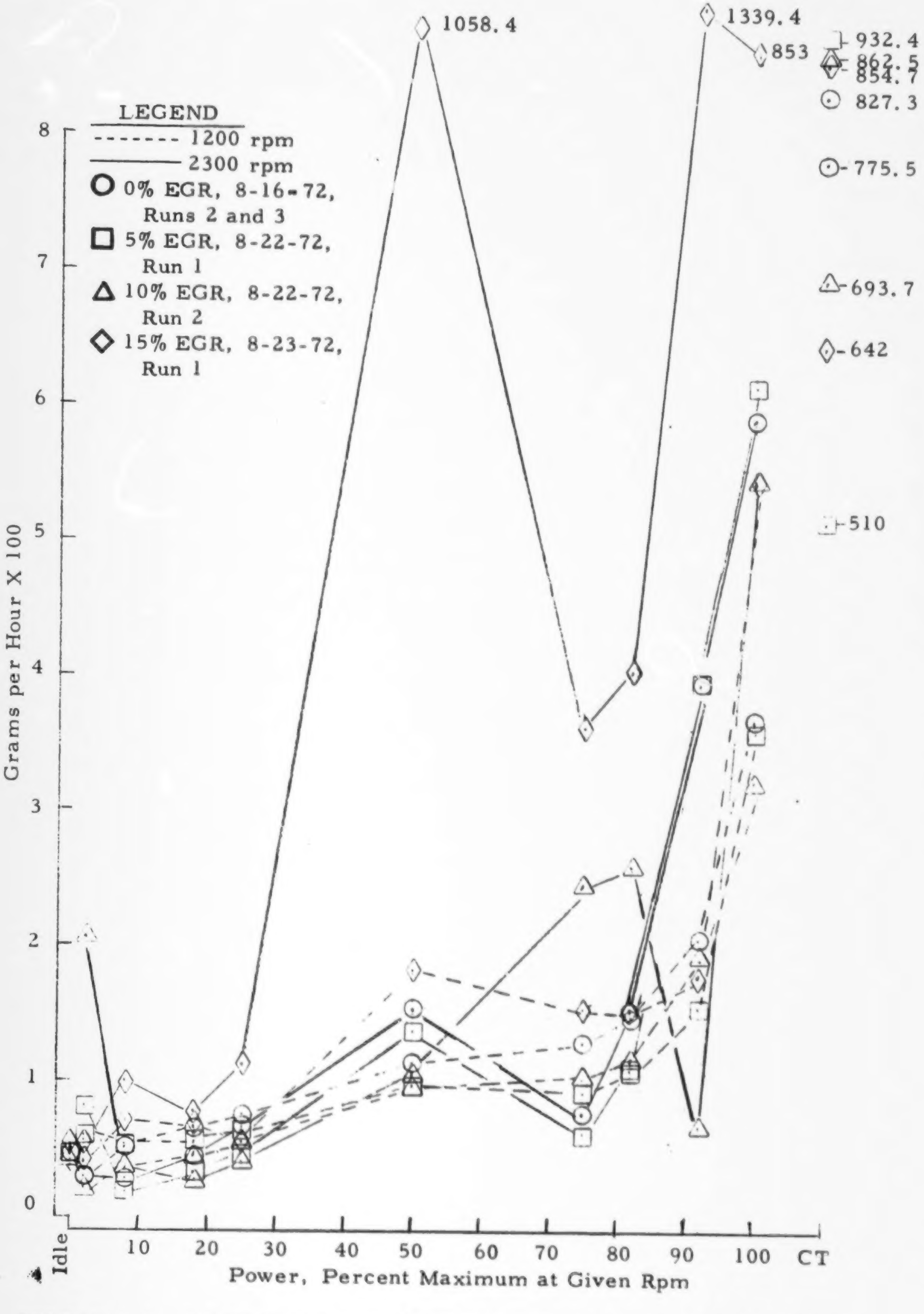
TABULAR DATA

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
 8-22-72 RUN-1 ENG.1-3 72-VERSION   STD TIMING STD JETS 5 %EGR
-------------------------------------------------------------------------------
             DYNA.         MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED   LOAD    HP   VAC. LB/HR  RATIO    ALDE.     HC       CO      CO2     NO
-------------------------------------------------------------------------------
  1   600     0.0     0   16.9   3.9   17.8        0   3690     .930   11.84     56
  2  1200     4.0     1   19.6   7.5   18.0        0   2231     .250   12.22     63
  3  1200    17.0     4   18.1   8.8   18.3        0   1671     .130   12.22    155
  4  1200    37.0     8   16.8   9.9   19.0        0   1499     .050   11.92    250
  5  1200    52.0    12   15.4  11.0   19.5        0   1486     .050   11.72    350
  6  1200   104.0    24   10.6  15.2   20.3        0   1636     .050   11.36    930
  7  1200   155.0    35    3.8  22.0   19.7        0   1110     .100   11.84   1063
  8  1200   170.0    39    2.5  23.2   19.6        0   1256     .100   11.92   1475
  9  1200   190.0    43    2.2  24.5   18.2        0   1787     .440   12.22   1663
 10  1200   207.0    47     .5  33.2   13.7        0   4170    6.860   10.25    210
 11   600     0.0     0   16.9   4.0   16.5        0   3235    1.630   11.92     60
 12  1200     0.0     0   21.9   4.4   24.7        0  22823     .440    6.21     12
 13  2300   223.0    98    1.7  64.0   13.1        0   3678    6.250   10.89    390
 14  2300   205.0    90    2.6  54.1   14.1        0   2546    4.020   11.60    913
 15  2300   183.0    80    2.8  50.1   16.1        0    689    1.660   12.34    620
 16  2300   167.0    73    2.8  47.4   17.1        0    381     .930   12.22    625
 17  2300   112.0    49   10.6  31.6   17.7        0   1230     .280   12.47   1988
 18  2300    56.0    25   15.1  22.7   18.3        0    580     .180   12.22   1050
 19  2300    40.0    18   16.4  20.3   18.8        0    451     .150   12.22    720
 20  2300    18.0     8   17.9  15.9   19.2        0    317     .150   11.84    395
 21  2300     4.0     2   19.0  14.2   19.6        0   1524     .150   11.60    235
 22   600     0.0     0   17.3   4.2   16.9        0   3149    1.550   11.92     59
 23  2300     0.0     0   23.9   4.7   23.3        0  39800     .280    4.84      7
-------------------------------------------------------------------------------
         CALCULATED GRAM/HR        WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC     CO     NO2  FAC.       HP  ALDE.     HC       CO     NO2
-------------------------------------------------------------------------------
  1   0.0   49.7    253     2.5  .070      0.0      I      R        R       R
  2   0.0   59.8    135     5.6  .060       .1    0.0  65.42    148.1     6.1
  3   0.0   53.3     84    16.4  .060       .2    0.0  13.72     21.6     4.2
  4   0.0   55.6     37    30.8  .050       .4    0.0   6.57      4.4     3.6
  5   0.0   62.2     42    48.6  .030       .4    0.0   5.24      3.6     4.1
  6   0.0   97.5     60   183.9  .060      1.4    0.0   4.10      2.5     7.7
  7   0.0   92.0    167   292.2 0.000      0.0    0.0   2.60      4.7     8.3
  8   0.0  108.8    175   424.3  .040      1.6    0.0   2.80      4.5    10.9
  9   0.0  154.7    769   477.4 0.000      0.0    0.0   3.56     17.7    11.0
 10   0.0  358.3  11906    59.9 0.000      0.0    0.0   7.58    251.7     1.3
 11   0.0   42.3    431     2.6  .070      0.0      I      R        R       R
 12   0.0  510.0    199      .9  .120      0.0      I      R        R       R
 13   0.0  609.9  20934   214.7  .025      2.4    0.0   6.25    214.4     2.2
 14   0.0  393.6  12553   468.6  .055      4.9    0.0   4.38    134.8     5.2
 15   0.0  111.3   5416   332.5  .035      2.8    0.0   1.39     67.6     4.1
 16   0.0   62.2   3063   338.3  .060      4.4    0.0    .85     41.9     4.6
 17   0.0  136.9    630   734.9  .060      2.9    0.0   2.79     12.8    15.0
 18   0.0   47.9    301   288.1 0.000      0.0    0.0   1.95     12.3    11.7
 19   0.0   33.5    225   177.3  .065      1.1    0.0   1.91     12.8    10.1
 20   0.0   19.0    182    78.7 0.000      0.0    0.0   2.41     23.1    10.0
 21   0.0   82.5    164    42.2 0.000      0.0    0.0  47.09     93.6    24.1
 22   0.0   43.5    433     2.7  .080      0.0      I      R        R       R
 23   0.0  932.4    133      .5  .060      0.0      I      R        R       R

CYCLE COMPOSITE     HC      8.969    GRAM/BHP HR
                    CO     78.442    GRAM/BHP HR
                    NO2     6.684    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .781      LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-22-72 RUN-2 ENG.1-3 72 VERSION 6 BTDC 10% EGR
-------------------------------------------------------------------------------------
              DYNA.         MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED     LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO        CO2      NO
-------------------------------------------------------------------------------------
  1    600      0.0     0   17.0    4.2   18.1        0   3318    1.050     13.48      54
  2   1200      4.0     1   19.8    6.5   18.5        0   1133     .280     14.05      62
  3   1200     15.0     3   19.2    8.0   18.4        0   1426     .210     14.05     145
  4   1200     35.0     8   18.1    9.4   18.5        0   1625     .150     13.77     185
  5   1200     48.0    11   16.1   10.2   18.9        0   1655     .150     13.48     245
  6   1200     96.0    22    8.6   15.8   19.4        0   1802     .150     12.71     245
  7   1200    144.0    33    2.3   22.1   18.1        0   1397     .210     13.48     500
  8   1200    157.0    36    2.1   23.0   17.3        0   1630     .350     13.91     720
  9   1200    177.0    40    1.9   25.5   15.8        0   2636    1.730     14.05     515
 10   1200    192.0    44     .5   31.6   13.0        0   4416    8.320     10.89     135
 11    600      0.0     0   17.4    4.4   16.5        0   3107    1.120     14.05      59
 12   1200      0.0     0   22.0    4.3   18.4        0  44602     .520      7.56       8
 13   2300    205.0    90    1.6   63.9   13.9        0   3341    6.500     11.01     167
 14   2300    189.0    83    2.2   62.5   13.4        0    419    8.010      9.64     117
 15   2300    168.0    74    2.7   51.2   15.0        0   1794    3.240     12.71     280
 16   2300    154.0    67    2.8   48.7   15.0        0   1794    3.240     12.71     280
 17   2300    103.0    45    7.8   34.1   17.7        0    958     .250     13.48     465
 18   2300     51.0    22   13.7   23.7   18.8        0    499     .100     13.06     360
 19   2300     37.0    16   15.2   21.1   18.4        0    357     .070     12.59     275
 20   2300     16.0     7   16.3   19.3   19.4        0    502     .100     12.47     213
 21   2300      4.0     2   18.4   15.0   20.1        0   3657     .100     11.60     135
 22    600      0.0     0   17.4    4.3   17.7        0   2730    1.120     12.47      60
 23   2300      0.0     0   23.9    4.6   23.8        0  38613     .210      5.27       9
-------------------------------------------------------------------------------------
         CALCULATED GRAM/HR          WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2   FAC.      HP   ALDE.      HC        CO      NO2
-------------------------------------------------------------------------------------
  1    0.0   42.5     272     2.3   .070     0.0       I        R         R        R
  2    0.0   23.1     115     4.2   .060      .1     0.0    25.30     126.3      4.6
  3    0.0   35.9     107    12.1   .060      .2     0.0    10.48      31.2      3.5
  4    0.0   49.2      92    18.6   .050      .4     0.0     6.15      11.5      2.3
  5    0.0   55.5     102    27.3   .030      .3     0.0     5.06       9.3      2.5
  6    0.0   99.0     167    44.7   .060     1.3     0.0     4.51       7.6      2.0
  7    0.0  101.3     307   120.3  0.000     0.0     0.0     3.08       9.3      3.7
  8    0.0  117.9     511   172.9   .040     1.4     0.0     3.29      14.3      4.8
  9    0.0  190.0    2519   123.3  0.000     0.0     0.0     4.70      62.3      3.0
 10    0.0  322.1   12258    32.7  0.000     0.0     0.0     7.34     279.4       .7
 11    0.0   40.1     292     2.5   .070     0.0       I        R         R        R
 12    0.0  693.7     163      .4   .120     0.0       I        R         R        R
 13    0.0  542.6   21328    90.3   .025     2.2     0.0     6.04     237.6      1.0
 14    0.0   67.1   25928    62.5   .055     4.6     0.0      .81     313.3       .8
 15    0.0  258.3    9424   133.9   .035     2.6     0.0     3.51     128.1      1.8
 16    0.0  245.6    8964   127.3   .060     4.0     0.0     3.64     132.9      1.9
 17    0.0  107.2     565   172.7   .060     2.7     0.0     2.38      12.5      3.8
 18    0.0   40.6     164    97.3  0.000     0.0     0.0     1.82       7.4      4.4
 19    0.0   26.9     107    68.8   .065     1.1     0.0     1.66       6.6      4.2
 20    0.0   34.8     140    48.9  0.000     0.0     0.0     4.97      20.0      7.0
 21    0.0  206.2     114    25.3  0.000     0.0     0.0   117.73      65.0     14.4
 22    0.0   38.4     318     2.8   .080     0.0       I        R         R        R
 23    0.0  862.5      95      .6   .060     0.0       I        R         R        R

CYCLE COMPOSITE      HC      10.106      GRAM/BHP HR
                     CO     143.862      GRAM/BHP HR
                     NO2      2.191      GRAM/BHP HR
                     ALDE     0.000      GRAM/BHP HR
                     BSFC      .881        LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-23-72 RUN-1 ENG.1-3 72-VERSION   6 BTDC 15% EGR STD.TIMING +JETS
-----------------------------------------------------------------------------------
                 DYNA.         MAN. FUEL    A/F                DRY CONCENTRATION
MODE SPEED       LOAD     HP   VAC. LB/HR   RATIO     ALDE.     HC       CO       CO2      NO
-----------------------------------------------------------------------------------
  1   600         0.0      0   18.5    4.4   15.4         0   4424    2.600    11.92      45
  2  1200         3.0      1   19.3    8.3   16.9         0   1560     .310    13.77      80
  3  1200        11.0      3   18.2    8.8   17.0         0   2533     .280    13.33      81
  4  1200        25.0      6   16.5    9.7   17.5         0   2076     .130    13.06      94
  5  1200        35.0      8   15.2   10.9   17.8         0   1596     .130    12.82     101
  6  1200        70.0     16    7.8   16.1   18.6         0   3113     .150    11.92     104
  7  1200       105.0     24    2.0   22.9   16.0         0   2297     .770    13.77     145
  8  1200       115.0     26    2.0   23.5   15.7         0   2159    1.120    13.63     140
  9  1200       129.0     29    1.9   24.0   15.4         0   2568    1.800    13.48     139
 10  1200       140.0     32     .4   31.5   12.0         0   7057    9.060     8.93      49
 11   600         0.0      0   17.5    4.2   15.2         0   3994    2.440    12.82      53
 12  1200         0.0      0   22.3    4.5   16.7         0  43508    1.050     8.43       9
 13  2300       148.0     65    1.5   59.8   12.0         0   6103    9.280     9.50      56
 14  2300       136.0     60    1.7   61.0   11.4         0   9914   10.350     9.14      48
 15  2300       121.0     53    2.7   48.6   14.0         0   3119    4.540    12.22      80
 16  2300       111.0     49    2.8   47.8   14.3         0   2762    4.070    12.22      85
 17  2300        74.0     32    2.8   42.4   16.1         0   8258    1.590    12.59      84
 18  2300        37.0     16   11.5   26.0   18.0         0   1228     .150    12.47     125
 19  2300        27.0     12   13.0   23.8   18.3         0    919     .150    12.47     120
 20  2300        12.0      5   15.4   19.8   18.6         0   1404     .150    12.22     109
 21  2300         3.0      1   17.0   17.4   18.8         0   4114     .180    11.92      90
 22   600         0.0      0   17.4    4.2   16.2         0   3281    1.730    12.47      60
 23  2300         0.0      0   23.8    4.7   22.4         0  41222     .280     5.88       9
-----------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2  FAC.       HP   ALDE.       HC        CO       NO2
-----------------------------------------------------------------------------------
  1   0.0     59.0      701      2.0  .070      0.0       I        R         R         R
  2   0.0     41.2      166      7.0  .060       .0     0.0    60.18     241.6      10.2
  3   0.0     72.9      163      7.7  .060       .2     0.0    29.02      64.8       3.1
  4   0.0     68.2       86     10.2  .050       .3     0.0    11.93      15.1       1.8
  5   0.0     60.2       99     12.6  .030       .2     0.0     7.53      12.4       1.6
  6   0.0    183.6      179     20.4  .060      1.0     0.0    11.48      11.2       1.3
  7   0.0    161.6     1094     33.9 0.000      0.0     0.0     6.73      45.6       1.4
  8   0.0    153.8     1611     33.1  .040      1.1     0.0     5.85      61.3       1.3
  9   0.0    179.9     2548     32.3 0.000      0.0     0.0     6.10      86.4       1.1
 10   0.0    539.3    13987     12.4 0.000      0.0     0.0    16.86     437.3        .4
 11   0.0     48.6      600      2.1  .070      0.0       I        R         R         R
 12   0.0    642.1      313       .4  .120      0.0       I        R         R         R
 13   0.0    853.8    26223     26.0  .025      1.6     0.0    13.17     404.6        .4
 14   0.0   1339.4    28245     21.5  .055      3.3     0.0    22.49     474.2        .4
 15   0.0    402.7    11842     34.3  .035      1.9     0.0     7.60     223.5        .6
 16   0.0    361.4    10760     36.9  .060      2.9     0.0     7.44     221.4        .8
 17   0.0   1056.4     4117     35.7  .060      1.9     0.0    32.66     127.0       1.1
 18   0.0    113.7      280     38.4 0.000      0.0     0.0     7.02      17.3       2.4
 19   0.0     78.1      257     33.8  .065       .8     0.0     6.60      21.8       2.9
 20   0.0    100.8      218     26.0 0.000      0.0     0.0    19.18      41.4       4.9
 21   0.0    259.5      224     18.8 0.000      0.0     0.0 [illegible]7.55     174.6      14.3
 22   0.0     43.0      458      2.6  .080      0.0       I        R         R         R
 23   0.0    854.7      117       .6  .060      0.0       I        R         R         R

CYCLE COMPOSITE     HC      24.351     GRAM/BHP HR
                    CO     251.999     GRAM/BHP HR
                    NO2       .960     GRAM/BHP HR
                    ALDE     0.000     GRAM/BHP HR
                    BSFC     1.259       LB/BHP HR
```

ENGINE 1-3

EFFECT OF LABORATORY EGR ON EMISSIONS

GRAPHED RESULTS



373

FIGURE S-1. EFFECT OF LABORATORY EGR ON HC EMISSION RATE
ENGINE 1-3, 23 MODE TEST

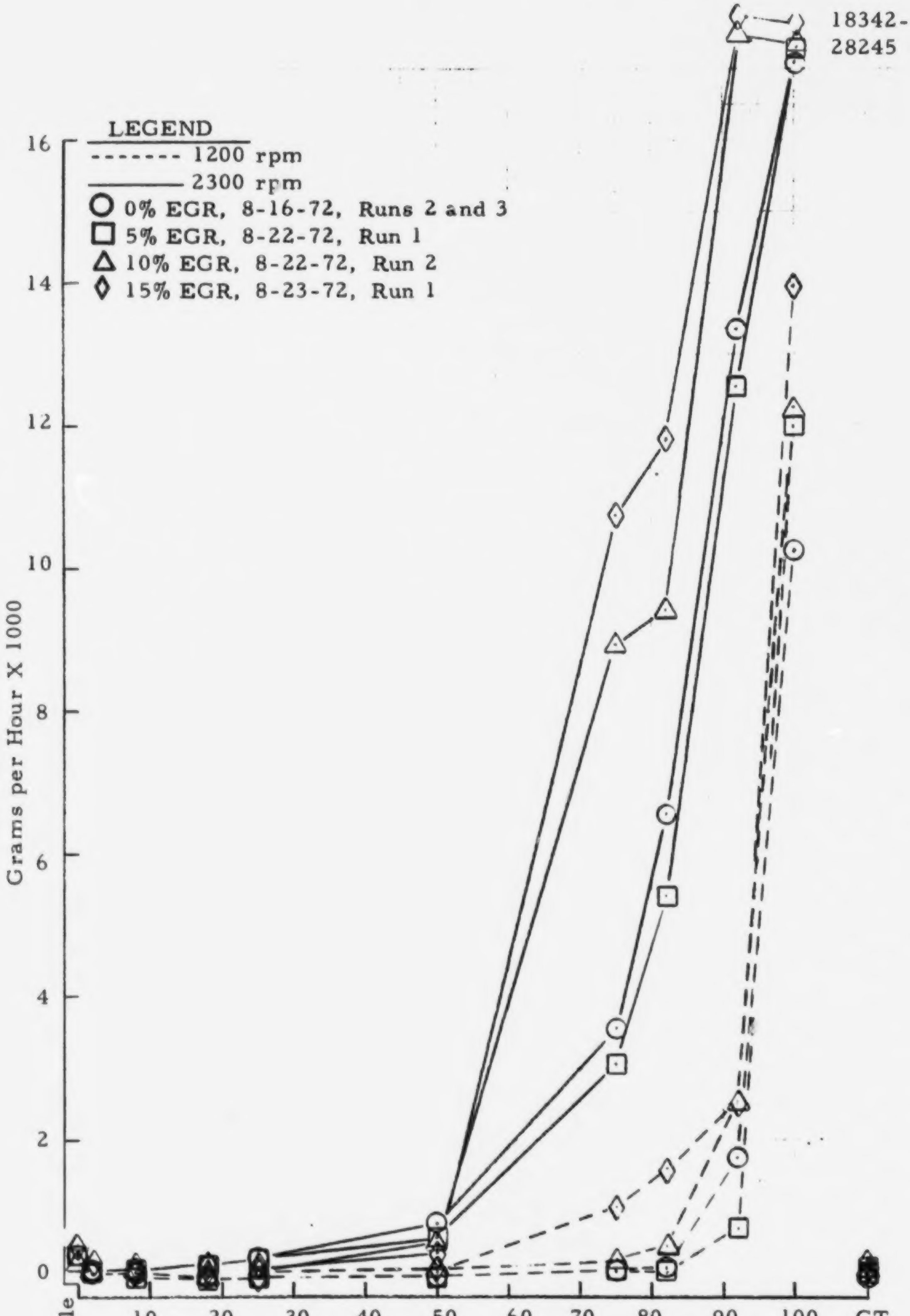


FIGURE S-2. EFFECT OF LABORATORY EGR ON CO EMISSION RATE
ENGINE 1-3, 23 MODE TEST

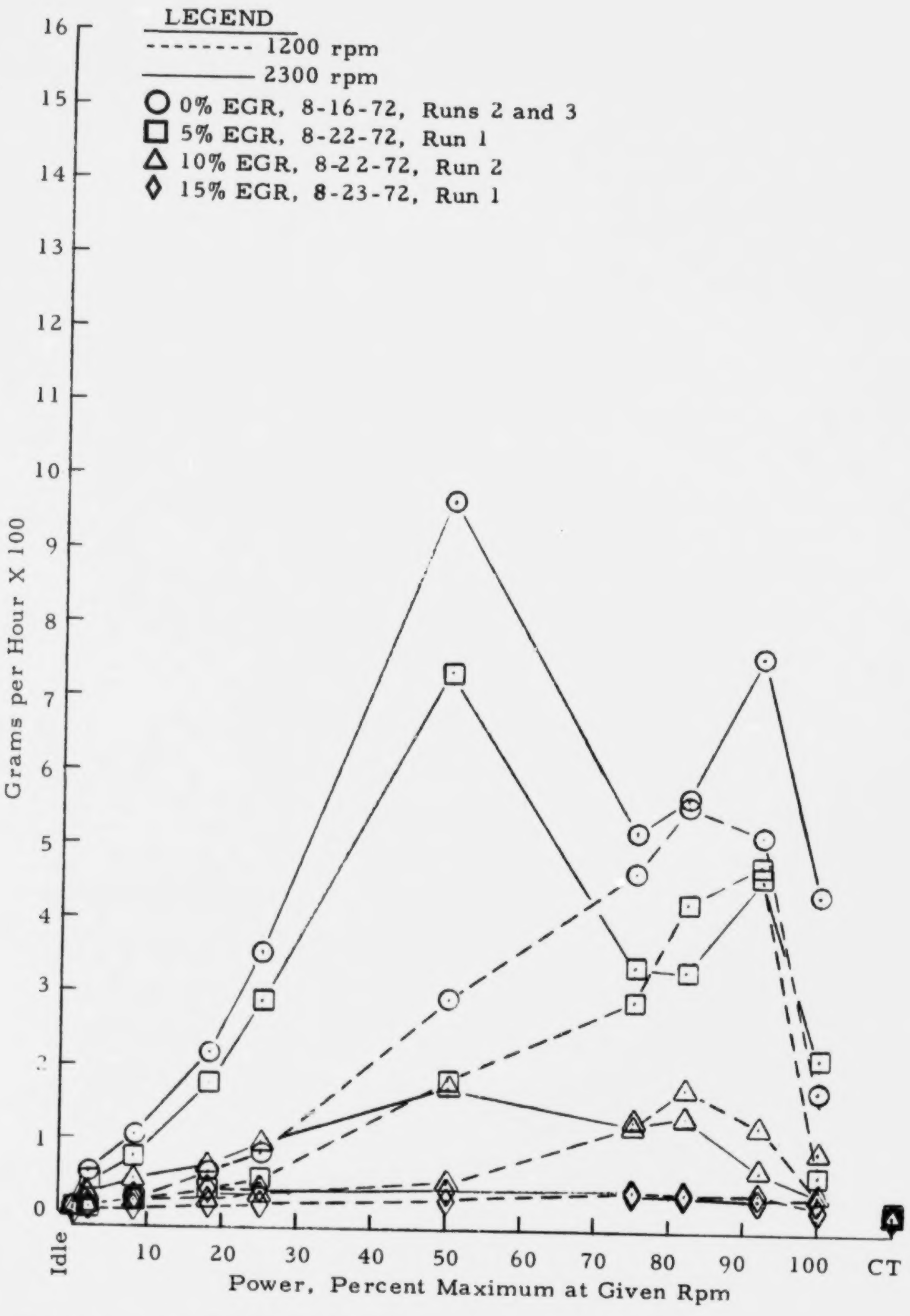


FIGURE S-3. EFFECT OF LABORATORY EGR ON NO_x (AS NO_2) EMISSION RATE ENGINE 1-3, 23 MODE TEST

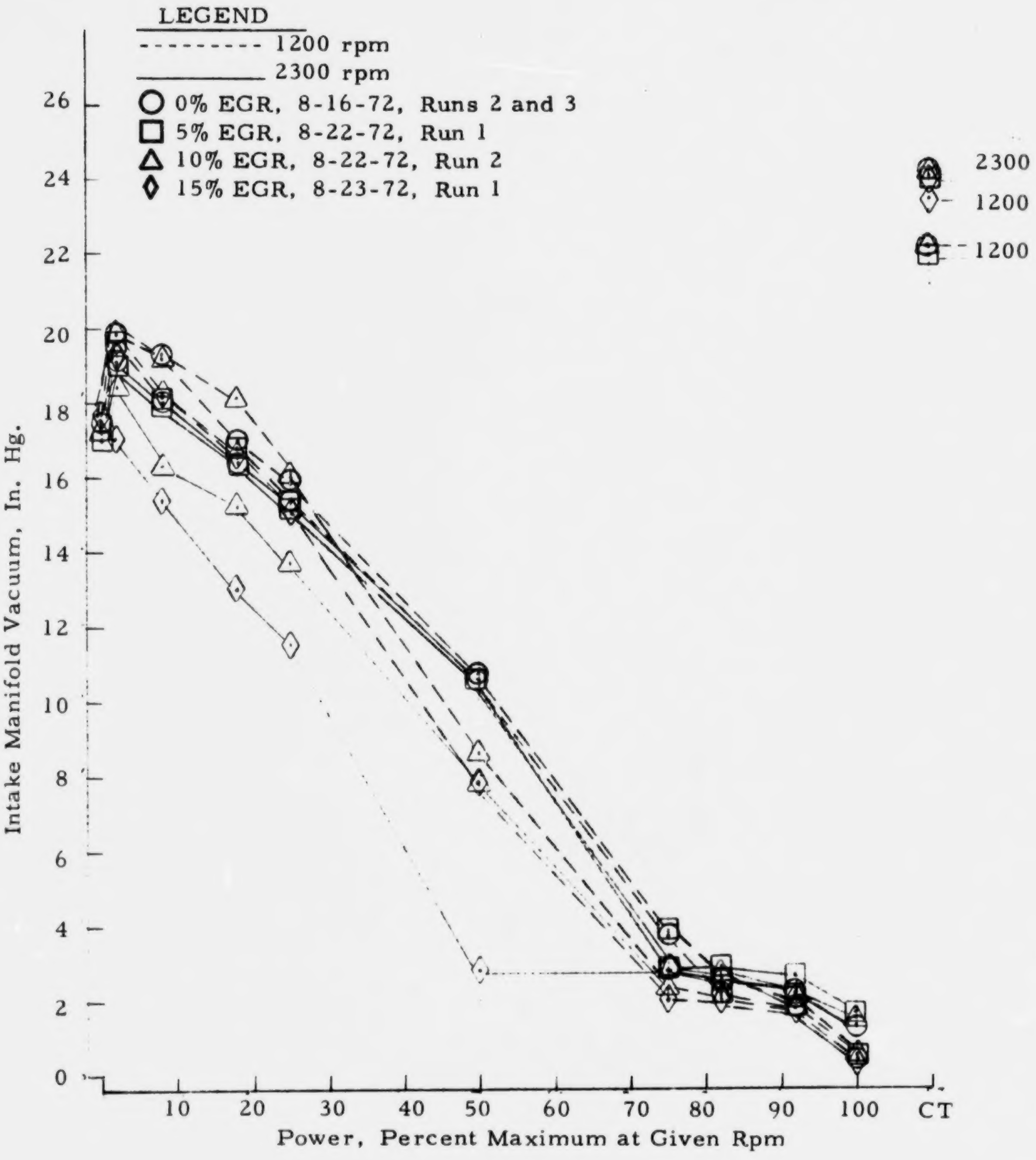


FIGURE S-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

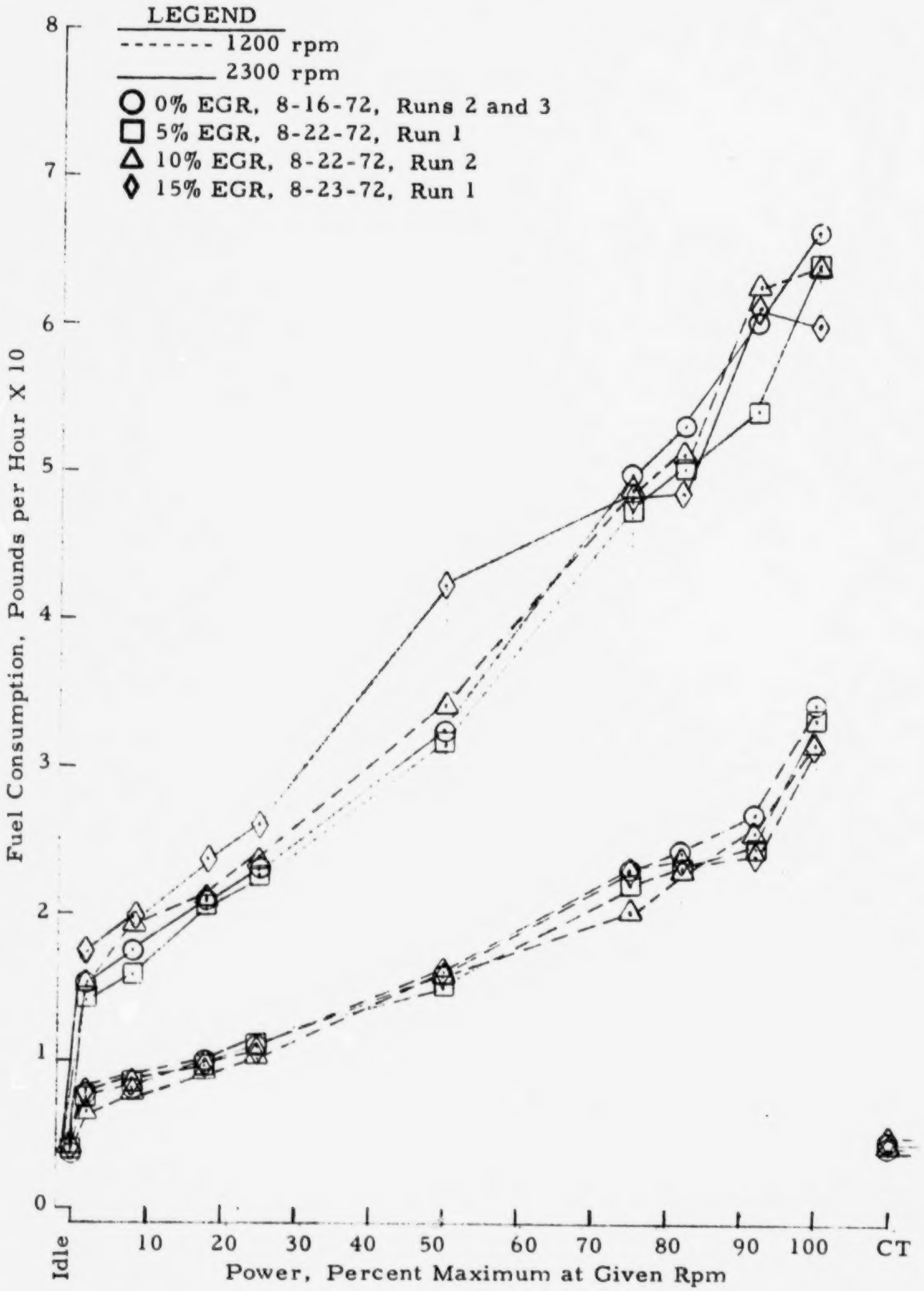


FIGURE S-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

APPENDIX T

ENGINE 1-3

EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 1-3

EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON EMISSIONS

TABULAR DATA

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
     8-24-72 RUN-1 ENG.1-3 72 VERSION  15 BTDC [600 RPM STD JETS W/AIR
-----------------------------------------------------------------------------------------------
                DYNA.          MAN.  FUEL     A/F                  DRY CONCENTRATION
MODE SPEED      LOAD    HP    VAC.  LB/HR   RATIO    ALDE.     HC       CO          CO2     NO
-----------------------------------------------------------------------------------------------
   1   600       0.0     0   18.9     3.1    18.2        0   3304    2.600         9.37     33
   2  1200       5.0     1   20.4     6.3    23.8        0    761     .210         9.25     57
   3  1200      20.0     5   19.4     7.4    22.9        0   1242     .180         9.50    184
   4  1200      44.0    10   17.7     9.1    23.5        0   1644     .100         9.50    575
   5  1200      62.0    14   15.9    10.6    22.8        0   1746     .070         9.78    820
   6  1200     124.0    28   10.1    16.2    22.1        0   1879     .070         9.93   1688
   7  1200     185.0    42    3.9    22.4    20.6        0   1564     .100        10.89   1813
   8  1200     203.0    46    2.3    23.8    20.1        0   1523     .100        11.13   1987
   9  1200     227.0    52    1.9    25.7    18.6        0   1894     .470        11.84   2225
  10  1200     247.0    56     .4    33.5    15.3        0   2953    4.260        10.43    863
  11   600       0.0     0   18.7     3.0    13.0        0   3608    2.780         9.14     39
  12  1200       0.0     0   23.0     3.4    30.0        0  41408     .180         2.93      7
  13  2300     262.0   115    1.4    66.0    14.6        0   1776    4.070        11.72    815
  14  2300     241.0   106    2.3    58.5    15.4        0    843    2.280        12.71   1575
  15  2300     215.0    94    2.5    52.0    17.0        0    150     .580        12.71   1250
  16  2300     197.0    86    2.7    48.7    18.2        0    217     .350        11.92   1237
  17  2300     131.0    57   10.0    33.1    20.1        0    829     .180        11.24   2850
  18  2300      66.0    29   14.8    23.2    22.3        0    672     .150         9.93   1337
  19  2300      47.0    21   16.3    20.4    23.3        0    555     .130         9.37    835
  20  2300      21.0     9   17.9    17.4    24.8        0    704     .100         8.93    440
  21  2300       5.0     2   19.3    14.5    26.5        0   4570     .100         8.04    205
  22   600       0.0     0   18.5     3.8    20.1        0   2504    1.630         9.25     46
  23  2300       0.0     0   23.9     4.2    38.1        0  54591     .020          .16      5
-----------------------------------------------------------------------------------------------
             CALCULATED GRAM/HR          WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.       HP   ALDE.       HC        CO       NO2
-----------------------------------------------------------------------------------------------
   1   0.0     37.8     600      1.2   .070      0.0      I         R         R         R
   2   0.0     22.8     127      5.7   .060       .1    0.0     19.97     111.3       5.0
   3   0.0     42.5     124     20.9   .060       .3    0.0      9.31      27.2       4.6
   4   0.0     69.5      85     80.7   .050       .5    0.0      6.91       8.5       8.0
   5   0.0     83.7      68    130.6   .030       .4    0.0      5.91       4.8       9.2
   6   0.0    135.5     102    404.1   .060      1.7    0.0      4.78       3.6      14.3
   7   0.0    142.6     184    548.5  0.000      0.0    0.0      3.37       4.4      13.0
   8   0.0    144.5     192    625.8   .040      1.9    0.0      3.12       4.1      13.5
   9   0.0    176.6     885    688.9  0.000      0.0    0.0      3.41      17.1      13.3
  10   0.0    299.5    8726    290.4  0.000      0.0    0.0      5.31     154.6       5.1
  11   0.0     40.0     622      1.4   .070      0.0      I         R         R         R
  12   0.0    880.7      77       .5   .120      0.0      I         R         R         R
  13   0.0    333.1   15414    507.3   .025      2.9    0.0      2.90     134.3       4.4
  14   0.0    148.3    8107    920.5   .055      5.8    0.0      1.41      76.8       8.7
  15   0.0     26.6    2077    735.7   .035      3.3    0.0       .28      22.1       7.8
  16   0.0     39.0    1271    738.4   .060      5.2    0.0       .45      14.7       8.6
  17   0.0    108.2     475   1235.0   .060      3.4    0.0      1.89       8.3      21.5
  18   0.0     69.7     314    460.5  0.000      0.0    0.0      2.41      10.9      15.9
  19   0.0     53.7     254    268.5   .065      1.3    0.0      2.61      12.4      13.0
  20   0.0     61.1     175    126.7  0.000      0.0    0.0      6.64      19.0      13.8
  21   0.0    349.6     155     52.1  0.000      0.0    0.0    159.68      70.6      23.8
  22   0.0     38.8     510      2.4   .080      0.0      I         R         R         R
  23   0.0   1844.3      14       .5   .060      0.0      I         R         R         R

CYCLE COMPOSITE      HC      10.409    GRAM/BHP HR
                     CO      44.742    GRAM/BHP HR
                     NO2     10.624    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .667      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-23-72 RUN-3 ENG.1-3 72-VERSION  W/AIR TDC
----------------------------------------------------------------------------------------
             DYNA.          MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO    ALDE.    HC        CO       CO2     NO
----------------------------------------------------------------------------------------
   1   600     0.0     0  16.2    3.2   21.6        0  1876     .310     10.89     65
   2  1200     4.0     1  19.6    6.8   25.1        0   436     .130      9.50     57
   3  1200    17.0     4  18.8    8.3   25.0        0   871     .150      9.50    130
   4  1200    38.0     9  16.8    9.4   24.5        0  1015     .130      9.78    265
   5  1200    53.0    12  15.1   10.5   24.0        0  1138     .130     10.09    350
   6  1200   105.0    24  10.4   15.3   23.1        0  1362     .100     10.55    820
   7  1200   158.0    36   2.0   23.8   20.5        0   756     .180     11.84   1212
   8  1200   172.0    39   1.8   24.7   19.7        0   704     .310     12.34   1300
   9  1200   193.0    44   1.7   27.4   18.0        0   727     .740     12.94   1150
  10  1200   210.0    48    .3   31.8   15.9        0  1085    2.730     12.59    530
  11   600     0.0     0  16.5    3.4   20.6        0  1940     .700     11.01     68
  12  1200     0.0     0  21.5    3.8   30.7        0 31956     .210      4.03     10
  13  2300   232.0   102   1.3   64.3   15.3        0   933    3.700     12.71    560
  14  2300   213.0    93   2.2   59.5   15.2        0  1151    4.020     12.34    840
  15  2300   190.0    83   2.4   54.3   16.4        0   260    1.770     13.48    855
  16  2300   174.0    76   2.6   50.5   17.9        0    42     .470     13.33    635
  17  2300   116.0    51  10.5   31.2   20.7        0   205     .210     11.72   1750
  18  2300    58.0    25  14.8   21.4   22.3        0   190     .150     10.89    800
  19  2300    42.0    18  15.8   20.6   23.4        0   200     .130     10.43    540
  20  2300    19.0     8  17.4   17.6   25.1        0   180     .100      9.64    300
  21  2300     5.0     2  18.5   15.2   26.8        0   477     .100      9.03    157
  22   600     0.0     0  16.7    3.4   21.7        0  1737     .520     11.01     70
  23  2300     0.0     0  23.4    4.0   42.8        0 53629     .070       .19      6
----------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2  FAC.      HP  ALDE.      HC       CO      NO2
----------------------------------------------------------------------------------------
   1   0.0    23.9       80     2.8  .070     0.0      I       R        R        R
   2   0.0    13.9       84     6.0  .060      .1    0.0   15.20     91.6      6.6
   3   0.0    35.7      117    16.7  .060      .2    0.0    8.67     30.2      4.3
   4   0.0    43.2      112    37.5  .050      .4    0.0    4.98     12.9      4.3
   5   0.0    52.5      121    53.6  .030      .4    0.0    4.33     10.0      4.4
   6   0.0    87.6      130   175.2  .060     1.4    0.0    3.65      5.4      7.3
   7   0.0    67.4      325   359.3 0.000     0.0    0.0    1.87      9.0     10.0
   8   0.0    62.0      552   380.1  .040     1.6    0.0    1.58     14.0      9.7
   9   0.0    65.7     1351   345.0 0.000     0.0    0.0    1.49     30.6      7.8
  10   0.0   101.4     5156   164.5 0.000     0.0    0.0    2.11    107.5      3.4
  11   0.0    25.1      183     2.4  .070     0.0      I       R        R        R
  12   0.0   740.8       98      .8  .120     0.0      I       R        R        R
  13   0.0   164.9    13209   328.6  .025     2.5    0.0    1.62    130.0      3.2
  14   0.0   188.6    13303   456.9  .055     5.1    0.0    2.02    142.6      4.9
  15   0.0    41.9     5765   457.7  .035     2.9    0.0     .50     69.3      5.5
  16   0.0     7.0     1575   349.8  .060     4.6    0.0     .09     20.7      4.6
  17   0.0    24.3      502   688.0  .060     3.0    0.0     .48      9.9     13.5
  18   0.0    16.7      266   233.1 0.000     0.0    0.0     .66     10.5      9.2
  19   0.0    17.7      232   158.3  .065     1.2    0.0     .96     12.6      8.6
  20   0.0    14.7      165    81.5 0.000     0.0    0.0    1.77     19.9      9.8
  21   0.0    35.8      152    39.3 0.000     0.0    0.0   16.37     69.3     17.9
  22   0.0    22.9      138     3.1  .080     0.0      I       R        R        R
  23   0.0  1730.5       46      .6  .060     0.0      I       R        R        R

CYCLE COMPOSITE    HC      9.845    GRAM/BHP HR
                   CO     63.782    GRAM/BHP HR
                   NO2     6.523    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .768      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-23-72 RUN-2 ENG.1-3 72-VERSION  STD. TIMING +JETS W/AIR
---------------------------------------------------------------------------------------------
              DYNA.            MAN. FUEL     A/F                   DRY CONCENTRATION
MODE SPEED    LOAD     HP   VAC. LB/HR    RATIO    ALDE.       HC        CO       CO2      NO
---------------------------------------------------------------------------------------------
  1    600      0.0     0   17.5     3.6    19.8
  2   1200      5.0     1   20.0     6.5    24.0        0    2735     1.410      9.93      41
  3   1200     18.0     4   19.2     7.3    24.2        0     761      .180      9.25      54
  4   1200     41.0     9   17.3     9.5    24.1        0     936      .150      9.37     141
  5   1200     57.0    13   15.8    10.8    23.9        0    1350      .100      9.50     440
  6   1200    114.0    26   10.5    15.0    22.9        0    1461      .100      9.64     575
  7   1200    171.0    39    3.1    22.7    20.9        0    1696      .070     10.09    1275
  8   1200    187.0    43    1.9    23.9    20.1        0    1137      .130     11.13    1450
  9   1200    210.0    48    1.7    27.3    18.0        0    1185      .180     11.48    1650
 10   1200    228.0    52     .3    31.9    15.5        0    1234      .810     12.34    1600
 11    600      0.0     0   17.6     3.5    19.3        0    1901     3.380     11.60     675
 12   1200      0.0     0   22.3     3.5    30.7        0    2563     1.940      9.78      46
 13   2300    250.0   109    1.3    67.3    14.9        0   38627      .210      3.04       7
 14   2300    230.0   101    2.2    59.8    14.8        0    1137     3.660     12.34     715
 15   2300    205.0    90    2.4    53.5    16.2        0    1463     3.700     12.22    1125
 16   2300    188.0    82    2.5    50.2    17.2        0     383     1.480     12.94    1050
 17   2300    125.0    55   10.0    33.2    19.9        0     105      .520     13.06     855
 18   2300     63.0    28   14.9    22.5    21.8        0     375      .210     11.48    2250
 19   2300     45.0    20   16.2    20.2    23.0        0     313      .150     10.43    1000
 20   2300     20.0     9   17.5    17.8    24.2        0     309      .130      9.93     680
 21   2300      5.0     2   19.2    14.0    26.3        0     261      .100      9.50     370
 22    600      0.0     0   17.4     3.6    20.2        0    1539      .130      8.54     167
 23   2300      0.0     0   24.0     3.5    45.1        0    2432     1.770      9.64      49
                                                        0   49082      .050       .13       6
---------------------------------------------------------------------------------------------
         CALCULATED GRAM/HR            WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.        HP  ALDE.       HC        CO      NO2
---------------------------------------------------------------------------------------------
  1    0.0    38.5      400      1.9   .070       0.0      I        R         R        R
  2    0.0    23.6      113      5.6   .060        .1    0.0    20.66      98.7      4.9
  3    0.0    32.2      104     16.1   .060        .2    0.0     7.84      25.4      3.9
  4    0.0    59.8       89     64.7   .050        .5    0.0     6.38       9.5      6.9
  5    0.0    72.4      100     94.6   .030        .4    0.0     5.56       7.7      7.3
  6    0.0   111.7       93    278.8   .060       1.6    0.0     4.29       3.6     10.7
  7    0.0   103.0      238    435.8  0.000       0.0    0.0     2.64       6.1     11.2
  8    0.0   109.1      335    504.2   .040       1.7    0.0     2.55       7.8     11.8
  9    0.0   115.1     1526    495.6  0.000       0.0    0.0     2.40      31.8     10.3
 10    0.0   181.4     6512    213.8  0.000       0.0    0.0     3.48     125.0      4.1
 11    0.0    34.0      519      2.0   .070       0.0      I        R         R        R
 12    0.0   862.2       95       .5   .120       0.0      I        R         R        R
 13    0.0   215.3    14006    449.7   .025       2.7    0.0     1.97     127.9      4.1
 14    0.0   247.0    12619    630.6   .055       5.5    0.0     2.45     125.3      6.3
 15    0.0    64.3     5018    585.1   .035       3.1    0.0      .72      55.9      6.5
 16    0.0    17.5     1760    475.6   .060       4.9    0.0      .21      21.4      5.8
 17    0.0    48.1      545    959.2   .060       3.3    0.0      .88      10.0     17.5
 18    0.0    30.1      291    319.3  0.000       0.0    0.0     1.09      10.6     11.6
 19    0.0    28.1      238    205.0   .065       1.3    0.0     1.43      12.1     10.4
 20    0.0    21.9      169    103.0  0.000       0.0    0.0     2.50      19.3     11.8
 21    0.0   110.8      189     40.0  0.000       0.0    0.0    50.59      86.3     18.3
 22    0.0    34.1      501      2.3   .080       0.0      I        R         R        R
 23    0.0  1531.4       32       .6   .060       0.0      I        R         R        R

CYCLE COMPOSTIE     HC       9.842    GRAM/BHP HR
                    CO      60.338    GRAM/BHP HR
                    NO2      8.303    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .712      LB/BHP HR
```

ENGINE 1-3

EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON EMISSIONS

GRAPHED RESULTS

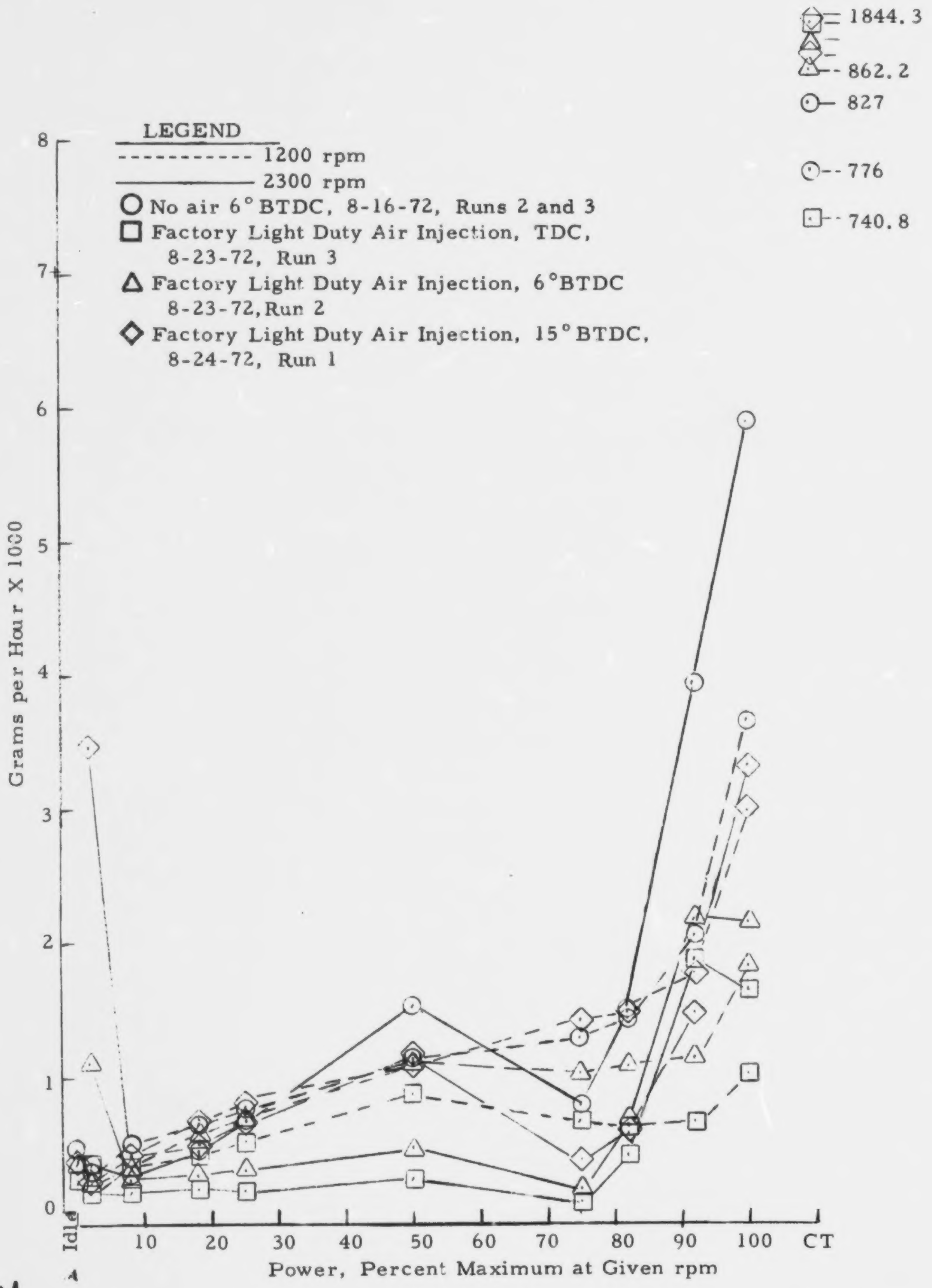


FIGURE T-1. EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON HC EMISSION RATE ENGINE 1-3, 23 MODE TEST

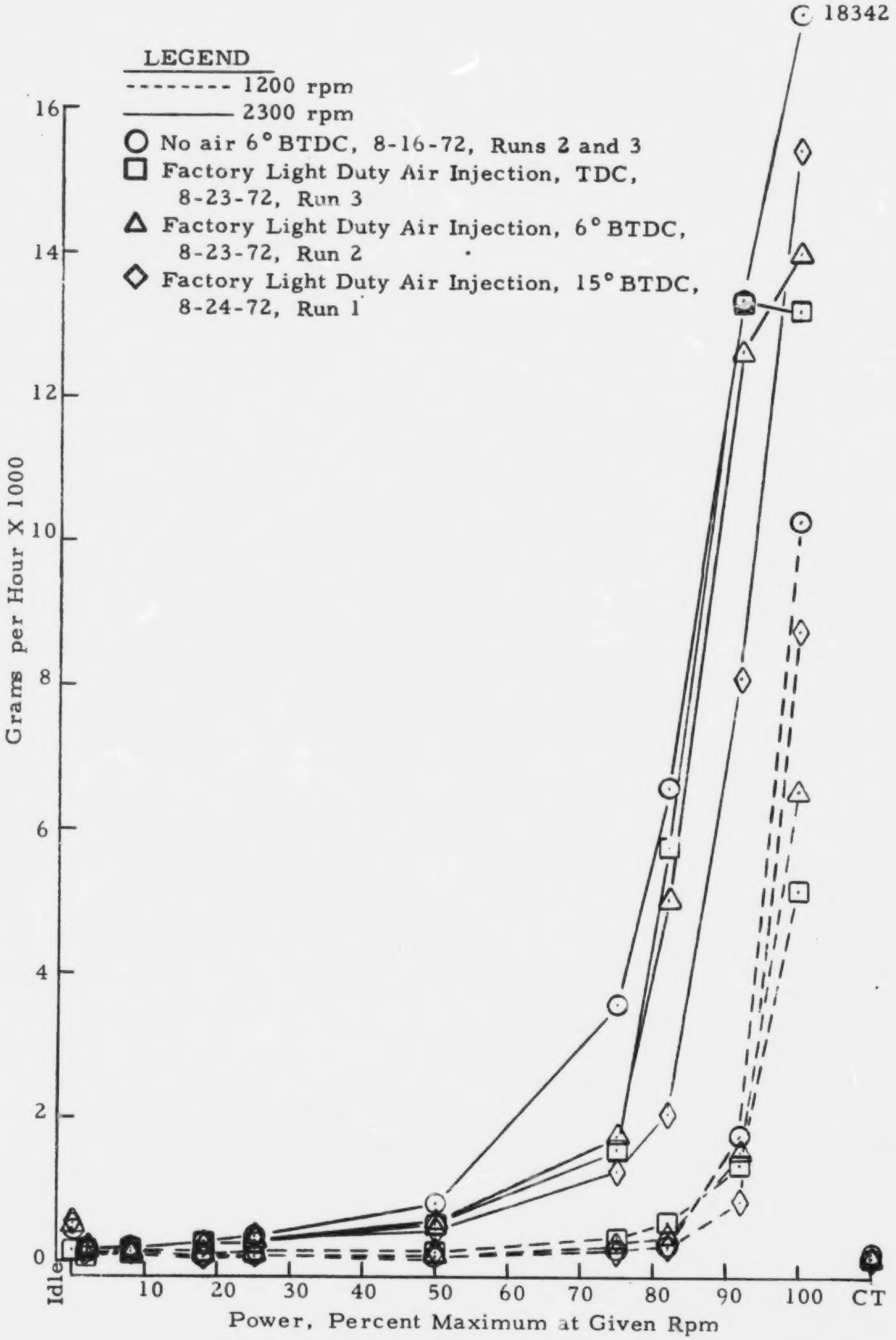


FIGURE T-2. EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON CO EMISSION RATE ENGINE 1-3, 23 MODE TEST

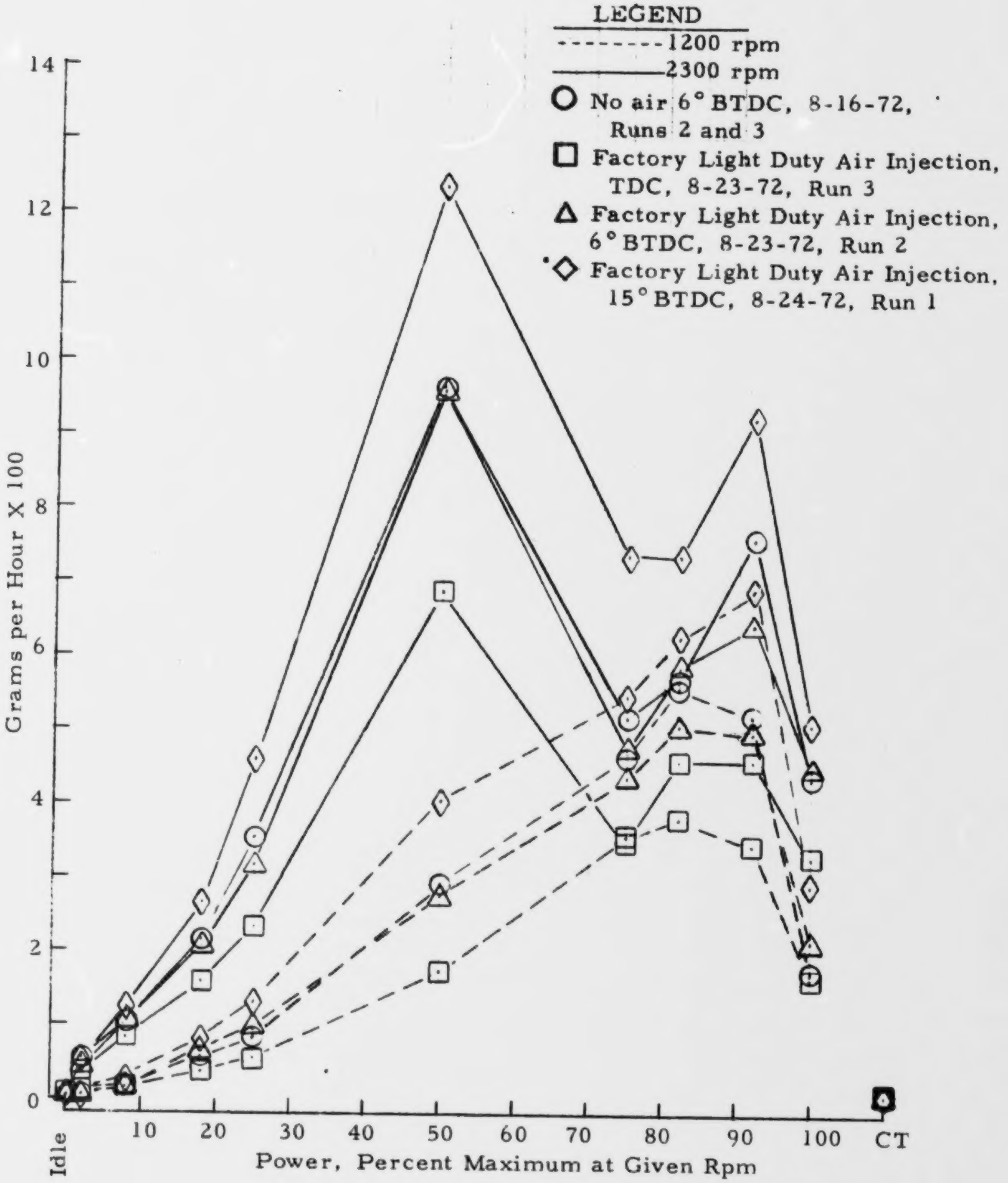


FIGURE T-3. EFFECT OF EXHAUST MANIFOLD AIR INJECTION ON NO_x (AS NO_2) EMISSION RATE ENGINE 1-3, 23 MODE TEST

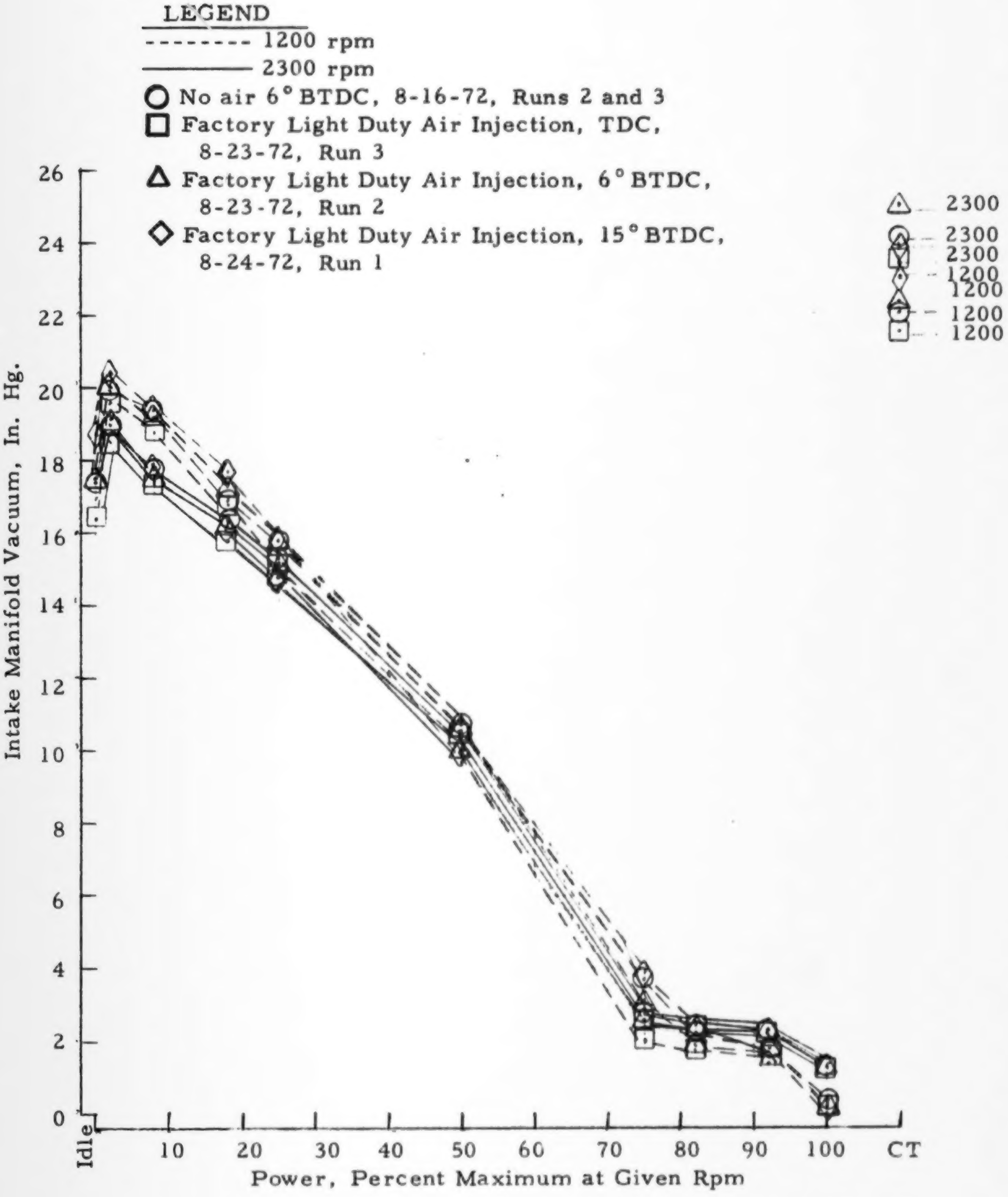


FIGURE T-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

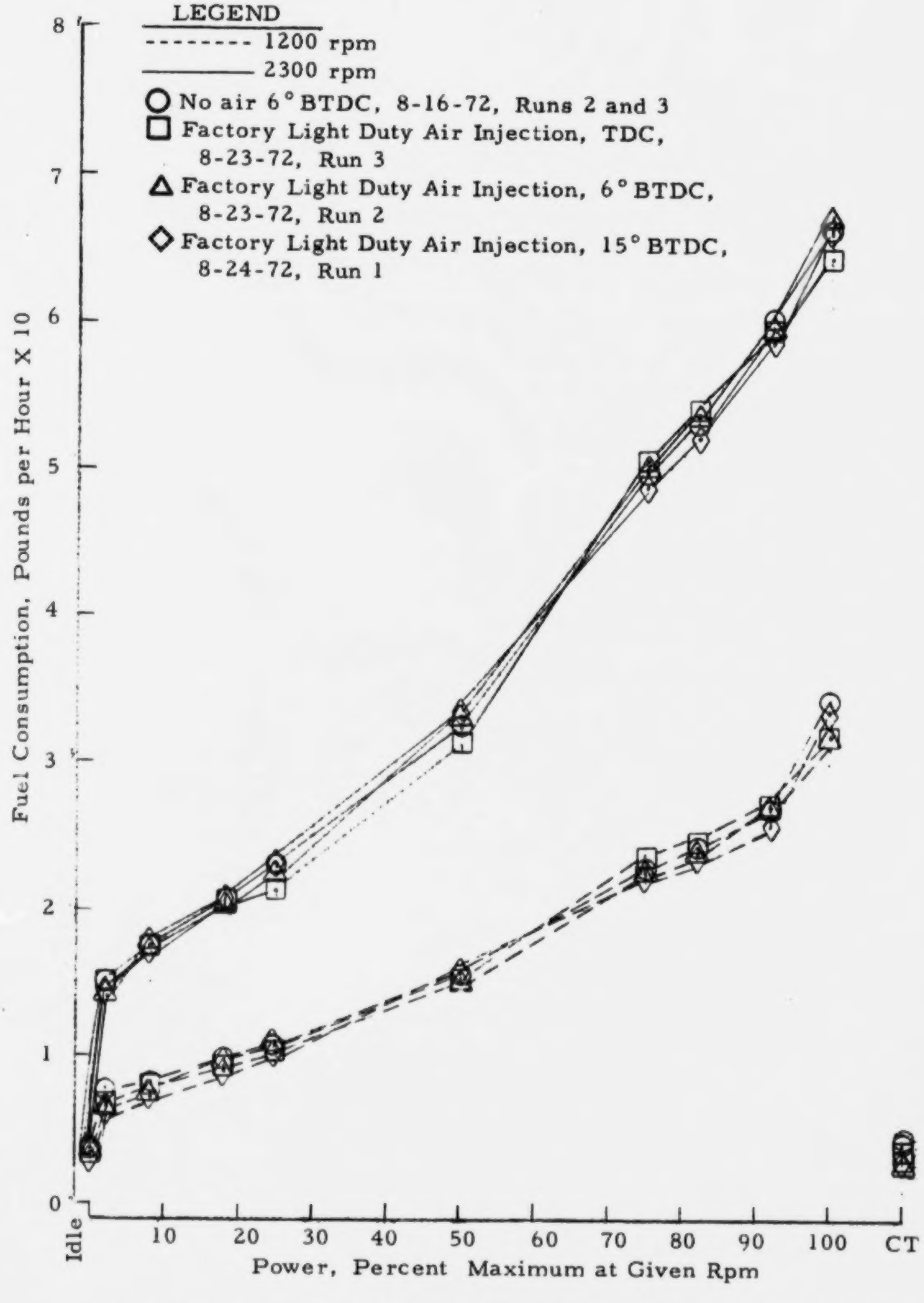


FIGURE T-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

APPENDIX U

ENGINE 1-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 1-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

TABULAR DATA

(BEFORE CATALYST)

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-24-72 RUN-2 ENG.1-3 72 VERSION 6 BTDC O-CAT STD TIM W/AIR BEFORE
------------------------------------------------------------------------------------
               DYNA.           MAN.  FUEL     A/F                 DRY CONCENTRATION
MODE SPEED     LOAD      HP    VAC.  LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
------------------------------------------------------------------------------------
   1   600      0.0       0    17.5    4.0    17.6        0    2191    1.160    10.66      31
   2  1200      5.0       1    19.8    6.6    20.6        0     383     .180    10.09      66
   3  1200     19.0       4    19.5    7.1    20.5        0     641     .180    10.09     100
   4  1200     42.0      10    18.3    8.5    20.2        0    1009     .180    10.25     270
   5  1200     59.0      13    16.6   10.2    19.9        0    1152     .100    10.43     515
   6  1200    118.0      27    10.0   16.0    19.5        0    1572     .070    10.66    1313
   7  1200    177.0      40     2.3   23.2    18.0        0     998     .130    11.60    1438
   8  1200    194.0      44     1.9   24.6    17.2        0     623     .210    11.92    1662
   9  1200    217.0      50     1.6   27.9    15.1        0     503     .930    13.18    1387
  10  1200    236.0      54      .3   32.5    13.3        0    1490    4.070    11.72     560
  11   600      0.0       0    17.5    3.9    16.8        0    2201    1.800    10.55      44
  12  1200      0.0       0    22.1    4.2    26.7        0   23559     .250     4.84       8
  13  2300    242.0     106     1.3   66.9    12.1        0    2983    6.370    10.78     410
  14  2300    223.0      98     2.2   60.2    12.6        0    2249    5.240    11.36     760
  15  2300    198.0      87     2.4   54.3    13.7        0    1052    3.010    12.47    1875
  16  2300    182.0      80     2.5   52.1    14.4        0     751    2.140    12.71     685
  17  2300    121.0      53    10.1   32.6    17.9        0     421     .150    11.48    1875
  18  2300     61.0      27    14.7   23.6    19.8        0     253     .100    10.55     750
  19  2300     44.0      19    15.7   21.8    20.1        0     216     .100    10.25     545
  20  2300     19.0       8    17.6   18.1    21.1        0     136     .070     9.64     260
  21  2300      5.0       2    18.7   15.8    22.1        0     542     .100     9.03     176
  22   600      0.0       0    17.7    4.1    17.4        0    1937    1.770     9.78      42
  23  2300      0.0       0    23.8    4.5    35.6        0   53186     .050      .33       8
------------------------------------------------------------------------------------
          CALCULATED GRAM/HR              WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO      NO2       FAC.      HP   ALDE.     HC       CO      NO2
------------------------------------------------------------------------------------
   1   0.0    33.0     353      1.6     .070      0.0      I       R        R        R
   2   0.0    11.1     106      6.4     .060       .1    0.0    9.74     92.4      5.6
   3   0.0    20.0     113     10.3     .060       .3    0.0    4.60     26.1      2.4
   4   0.0    36.9     133     32.8     .050       .5    0.0    3.85     13.9      3.4
   5   0.0    50.1      88     74.3     .030       .4    0.0    3.72      6.5      5.5
   6   0.0   104.8      94    290.5     .060      1.6    0.0    3.89      3.5     10.8
   7   0.0    88.7     234    424.6    0.000      0.0    0.0    2.19      5.8     10.5
   8   0.0    57.0     388    505.2     .040      1.8    0.0    1.29      8.8     11.4
   9   0.0    45.0    1679    411.7    0.000      0.0    0.0     .91     33.9      8.3
  10   0.0   137.8    7604    172.0    0.000      0.0    0.0    2.56    141.0      3.2
  11   0.0    31.0     512      2.1     .070      0.0      I       R        R        R
  12   0.0   602.8     129       .6     .120      0.0      I       R        R        R
  13   0.0   518.9   22379    236.7     .025      2.6    0.0    4.90    211.2      2.2
  14   0.0   365.1   17179    409.5     .055      5.4    0.0    3.74    175.9      4.2
  15   0.0   166.2    9609    983.8     .035      3.0    0.0    1.92    110.8     11.3
  16   0.0   118.9    6845    360.1     .060      4.8    0.0    1.49     85.9      4.5
  17   0.0    53.3     384    788.6     .060      3.2    0.0    1.01      7.2     14.9
  18   0.0    25.3     203    249.7    0.000      0.0    0.0     .95      7.6      9.3
  19   0.0    20.6     193    172.5     .065      1.3    0.0    1.07     10.0      9.0
  20   0.0    11.5     119     72.9    0.000      0.0    0.0    1.38     14.3      8.8
  21   0.0    42.3     158     45.7    0.000      0.0    0.0   19.32     72.0     20.9
  22   0.0    30.7     566      2.2     .080      0.0      I       R        R        R
  23   0.0  1905.1      36       .9     .060      0.0      I       R        R        R
CYCLE COMPOSITE   HC     10.368    GRAM/BHP HR
                  CO     98.659    GRAM/BHP HR
                  NO2     7.481    GRAM/BHP HR
                  ALDE    0.000    GRAM/BHP HR
                  BSFC     .745      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-25-72 RUN-1    ENG.1-3   1972 VER B O-CAT W/AIR 6 BTDC
-----------------------------------------------------------------------------------
                 DYNA.        MAN. FUEL    A/F                   DRY CONCENTRATION
MODE SPEED       LOAD    HP   VAC. LB/HR   RATIO     ALDE.     HC        CO        CO2      NO
-----------------------------------------------------------------------------------
   1    600       0.0     0   17.5    3.9   17.7          0   2340   1.340     11.01      58
   2   1200       5.0     1   19.9    7.6   20.7          0    346    .210     10.43      55
   3   1200      18.0     4   19.2    8.2   20.5          0    704    .210     10.55     122
   4   1200      41.0     9   17.8    9.4   20.2          0    991    .150     10.78     325
   5   1200      58.0    13   16.0   10.9   20.4          0   1034    .130     10.66     430
   6   1200     115.0    26   10.2   15.3   19.7          0   1456    .130     11.01     988
   7   1200     173.0    40    2.1   24.2   18.0          0    585    .150     12.22    1250
   8   1200     189.0    43    1.8   25.8   17.0          0    442    .280     12.71    1462
   9   1200     212.0    48    1.7   27.5   15.7          0    379    .550     13.77    1412
  10   1200     230.0    53     .3   33.4   13.4          0   1231   4.020     12.22     505
  11    600       0.0     0   17.6    4.0   17.2          0   1899   1.660     11.01      42
  12   1200       0.0     0   22.0    4.3   27.8          0  27130    .250      4.45       8
  13   2300     242.0   106    1.3   66.4   12.2          0   2695   6.440     10.78     420
  14   2300     223.0    98    1.7   59.1   12.8          0   1967   5.030     11.92     845
  15   2300     198.0    87    2.3   54.5   13.7          0    929   3.190     12.71     753
  16   2300     182.0    80    2.4   51.7   14.3          0    628   2.210     13.18     675
  17   2300     121.0    53   10.1   32.7   17.6          0    334    .180     12.22    1938
  18   2300      61.0    27   14.6   24.0   19.6          0    226    .100     11.01     850
  19   2300      44.0    19   15.9   21.3   20.0          0    173    .100     10.78     570
  20   2300      19.0     8   17.5   18.1   20.8          0    493    .070     10.25     300
  21   2300       5.0     2   18.8   15.4   22.1          0    696    .070      9.37     180
  22    600       0.0     0   17.5    4.0   17.8          0   1749   1.410     10.55      44
  23   2300       0.0     0   23.8    4.4   40.4          0  47636    .050       .26       4
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO     NO2  FAC.       HP  ALDE.      HC       CO      NO2
-----------------------------------------------------------------------------------
   1    0.0    32.9      381     2.7  .070      0.0      I       R        R        R
   2    0.0    11.2      137     5.9  .060       .1    0.C    9.78    119.9      5.2
   3    0.0    24.2      146    14.0  .060       .2    0.0    5.88     35.4      3.4
   4    0.0    38.3      117    41.7  .050       .5    0.0    4.09     12.5      4.5
   5    0.0    46.9      119    64.8  .030       .4    0.0    3.54      9.0      4.9
   6    0.0    89.5      161   201.6  .060      1.6    0.0    3.41      6.1      7.7
   7    0.0    51.7      268   366.5 0.000      0.0    0.0    1.31      6.8      9.3
   8    0.0    39.7      508   436.0  .040      1.7    0.0     .92     11.8     10.1
   9    0.0    33.0      965   407.4 0.000      0.0    0.0     .68     19.9      8.4
  10    0.0   114.0     7519   155.2 0.000      0.0    0.0    2.17    143.1      3.0
  11    0.0    26.8      473     2.0  .070      0.0      I       R        R        R
  12    0.0   713.8      133      .7  .120      0.0      I       R        R        R
  13    0.0   464.2    22403   240.1  .025      2.6    0.0    4.38    211.4      2.3
  14    0.0   307.5    15885   438.6  .055      5.4    0.0    3.15    162.7      4.5
  15    0.0   143.6     9961   391.3  .035      3.0    0.0    1.66    114.9      4.5
  16    0.0    95.3     6775   340.1  .060      4.8    0.0    1.20     85.0      4.3
  17    0.0    39.9      434   767.4  .060      3.2    0.0     .75      8.2     14.5
  18    0.0    22.1      198   276.0 0.000      0.0    0.0     .83      7.4     10.3
  19    0.0    15.4      179   167.8  .065      1.3    0.0     .80      9.3      8.7
  20    0.0    39.0      112    78.9 0.000      0.0    0.0    4.69     13.5      9.5
  21    0.0    51.1      104    43.9 0.000      0.0    0.0   23.35     47.4     20.0
  22    0.0    26.2      426     2.2  .080      0.0      I       R        R        R
  23    0.0  1873.9       40      .6  .060      0.0      I       R        R        R

CYCLE COMPOSITE    HC      10.480    GRAM/BHP HR
                   CO      96.753    GRAM/BHP HR
                   NO2      6.324    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .752      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-25-72 RUN-3   ENG.1-3   1972 VER B O-CAT W/AIR MODI TDC
-------------------------------------------------------------------------------
              DYNA.       MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC        CO      CO2     NO
-------------------------------------------------------------------------------
  1   600      0.0     0  16.7   3.8   17.9       0  1965   1.050   10.89     51
  2  1200      4.0     1  20.0   7.6   22.2       0   413    .130    9.37     50
  3  1200     16.0     4  19.1   8.5   21.3       0   541    .150    9.93    138
  4  1200     37.0     8  17.5   9.6   20.8       0   679    .130   10.09    275
  5  1200     52.0    12  15.9  10.7   20.8       0   701    .130   10.25    390
  6  1200    103.0    24  10.4  15.6   20.2       0  1153    .100   10.55    850
  7  1200    155.0    35   1.8  23.5   18.4       0   344    .100   11.72   1088
  8  1200    169.0    39   1.7  25.0   17.5       0   295    .150   12.22   1288
  9  1200    190.0    43   1.6  27.4   15.9       0   212    .350   13.33   1313
 10  1200    206.0    47    .3  32.8   13.6       0   917   3.520   12.34    500
 11   600      0.0     0  16.8   3.9   17.3       0  1895   1.590   10.78     59
 12  1200      0.0     0  22.0   4.2   27.2       0 26115    .280    4.54     16
 13  2300    222.0    97   1.3  65.7   13.2       0   792   4.160   11.84    315
 14  2300    204.0    89   2.1  58.3   14.2       0   214   2.110   12.94    705
 15  2300    182.0    80   2.3  54.2   15.2       0    74    .850   12.94    620
 16  2300    167.0    73   2.4  51.5   15.8       0    67    .470   12.94    555
 17  2300    111.0    49  10.5  32.0   19.7       0   368    .130   10.43   1538
 18  2300     56.0    25  14.9  23.5   20.9       0   246    .100    9.78    600
 19  2300     40.0    18  15.7  21.6   20.7       0   196    .070    9.37    500
 20  2300     18.0     8  17.2  18.6   20.7       0   135    .070    9.14    275
 21  2300      4.0     2  18.3  16.5   20.9       0   184    .070    8.93    188
 22   600      0.0     0  16.7   3.8   16.8       0  1814   1.520    9.93     48
 23  2300      0.0     0  23.7   4.6   25.5       0 54621    .050     .19      5
-------------------------------------------------------------------------------
       CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------
  1   0.0    27.9     301     2.4  .070     0.0     I        R        R       R
  2   0.0    14.9      95     6.0  .060      .1   0.0    16.34    103.8     6.6
  3   0.0    20.6     115    17.4  .060      .2   0.0     5.63     31.5     4.8
  4   0.0    28.7     111    38.6  .050      .4   0.0     3.40     13.1     4.6
  5   0.0    32.6     122    60.1  .030      .4   0.0     2.74     10.3     5.1
  6   0.0    75.8     133   185.5  .060     1.4   0.0     3.22      5.6     7.9
  7   0.0    30.9     182   324.8 0.000     0.0   0.0      .87      5.1     9.2
  8   0.0    27.0     277   391.1  .040     1.5   0.0      .70      7.2    10.1
  9   0.0    19.2     641   395.4 0.000     0.0   0.0      .44     14.8     9.1
 10   0.0    85.6    6632   154.8 0.000     0.0   0.0     1.82    14  9     3.3
 11   0.0    26.7     452     2.8  .070     0.0     I        R        R       R
 12   0.0   669.5     145     1.4  .120     0.0     I        R        R       R
 13   0.0   146.8   15575   193.8  .025     2.4   0.0     1.51    160.2     2.0
 14   0.0    37.6    7479   410.7  .055     4.9   0.0      .42     83.7     4.6
 15   0.0    13.3    3059   366.8  .035     2.8   0.0      .17     38.4     4.6
 16   0.0    11.7    1653   320.8  .060     4.4   0.0      .16     22.6     4.4
 17   0.0    50.4     360   699.4  .060     2.9   0.0     1.04      7.4    14.4
 18   0.0    26.4     217   214.4 0.000     0.0   0.0     1.08      8.9     8.7
 19   0.0    20.3     146   171.9  .065     1.1   0.0     1.16      8.4     9.8
 20   0.0    12.3     129    83.5 0.000     0.0   0.0     1.56     16.4    10.6
 21   0.0    15.3     117    51.8 0.000     0.0   0.0     8.72     67.0    29.6
 22   0.0    26.9     455     2.4  .080     0.0     I        R        R       R
 23   0.0  1998.7      37      .6  .060     0.0     I        R        R       R

CYCLE COMPOSITE     HC     10.079    GRAM/BHP HR
                    CO     52.584    GRAM/BHP HR
                    NO2     6.434    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .818      LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-25-72 RUN-2      ENG.1-3    1972 VER B O-CAT W/AIR MODI 6 BTDC
-------------------------------------------------------------------------------
               DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED     LOAD     HP    VAC. LB/HR   RATIO    ALDE.    HC       CO       CO2      NO
-------------------------------------------------------------------------------
  1    600      0.0      0    17.7   4.1    18.1        0   1970    1.200     10.66     41
  2   1200      4.0      1    20.0   7.2    21.3        0    334     .180      9.93     59
  3   1200     18.0      4    19.4   8.1    21.4        0    611     .150      9.78    145
  4   1200     40.0      9    18.2   9.2    21.1        0    820     .130      9.93    360
  5   1200     56.0     13    16.2  10.8    20.7        0    867     .100     10.43    520
  6   1200    111.0     25    10.8  15.7    19.9        0   1200     .100     10.78   1125
  7   1200    167.0     38     2.7  23.6    18.5        0    599     .130     11.72   1200
  8   1200    182.0     42     1.9  24.5    18.1        0    528     .130     11.92   1375
  9   1200    204.0     47     1.7  26.7    16.4        0    404     .390     12.71   1575
 10   1200    222.0     51      .3  33.7    13.5        0   1137    3.790     12.22    570
 11    600      0.0      0    17.6   4.0    17.3        0   1828    1.840     10.56     45
 12   1200      0.0      0    22.8   4.4    27.4        0  24074     .210      4.84     22
 13   2300    236.0    103     1.3  66.7    13.2        0    909    4.160     12.09    385
 14   2300    217.0     95     1.9  66.4    12.5        0   1155    5.670     11.13    270
 15   2300    194.0     85     2.4  53.3    15.0        0    111    1.010     13.33    760
 16   2300    177.0     78     2.5  50.2    15.7        0     61     .470     13.06    600
 17   2300    118.0     52    10.4  32.0    19.5        0    429     .150     10.66   1800
 18   2300     59.0     26    14.8  23.0    20.5        0    279     .100     10.09    800
 19   2300     42.0     18    16.0  21.3    21.1        0    229     .070      9.64    550
 20   2300     19.0      8    17.6  18.3    22.1        0    166     .050      9.14    290
 21   2300      5.0      2    18.5  16.0    23.1        0    405     .050      8.68    195
 22    600      0.0      0    17.5   4.0    18.2        0   1830    1.450      9.64     44
 23   2300      0.0      0    23.8   4.5    38.3        0  51113     .050       .19      6
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.      HC       CO      NO2
-------------------------------------------------------------------------------
  1   0.0    30.4      374     2.1   .070      0.0     I        R        R        R
  2   0.0    10.7      117     6.3   .060       .1   0.0    11.75    128.1      6.9
  3   0.0    22.5      111    17.7   .060       .2   0.0     5.47     27.1      4.3
  4   0.0    33.7      108    49.2   .050       .5   0.0     3.69     11.8      5.4
  5   0.0    40.0       93    79.7   .030       .4   0.0     3.13      7.3      6.2
  6   0.0    77.7      131   241.8   .060      1.5   0.0     3.06      5.2      9.5
  7   0.0    53.9      236   358.1  0.000      0.0   0.0     1.41      6.2      9.4
  8   0.0    48.5      241   419.2   .040      1.7   0.0     1.17      5.8     10.1
  9   0.0    37.2      726   481.9  0.000      0.0   0.0      .80     15.6     10.3
 10   0.0   107.8     7258   179.4  0.000      0.0   0.0     2.12    143.1      3.5
 11   0.0    26.4      536     2.2   .070      0.0     I        R        R        R
 12   0.0   644.3      114     2.0   .120      0.0     I        R        R        R
 13   0.0   168.3    15559   236.7   .025      2.6   0.0     1.63    150.5      2.3
 14   0.0   205.7    20393   159.6   .055      5.2   0.0     2.16    214.6      1.7
 15   0.0    18.7     3437   425.1   .035      3.0   0.0      .22     40.5      5.0
 16   0.0    10.2     1597   335.1   .060      4.7   0.0      .13     20.6      4.3
 17   0.0    57.4      405   799.3   .060      3.1   0.0     1.11      7.8     15.5
 18   0.0    28.5      206   271.2  0.000      0.0   0.0     1.10      8.0     10.5
 19   0.0    22.7      140   181.3   .065      1.2   0.0     1.24      7.6      9.9
 20   0.0    15.0       91    86.8  0.000      0.0   0.0     1.80     10.9     10.4
 21   0.0    33.5       84    53.6  0.000      0.0   0.0    15.32     38.2     24.5
 22   0.0    29.5      471     2.4   .080      0.0     I        R        R        R
 23   0.0  1949.7       39      .8   .060      0.0     I        R        R        R

CYCLE COMPOSITE     HC      9.719    GRAM/BHP HR
                    CO     79.677    GRAM/BHP HR
                    NO2     6.141    GRAM/BHP HR
                    ALDE    0.000    GRAM/BHP HR
                    BSFC     .782      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-28-72 RUN-1 ENG.1-3 72 VERSION  15 BTDC  600 RPM B W/AIR MOD  O-CAT
-----------------------------------------------------------------------------------
              DYNA.         MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.    HC       CO      CO2    NO
-----------------------------------------------------------------------------------
  1   600      0.0     0   20.2   4.0   18.3         0  1446   1.590    10.55    26
  2  1200      5.0     1   20.9   7.1   21.9         0   443    .280     9.78    54
  3  1200     20.0     5   19.9   8.5   21.1         0   975    .550     9.78   132
  4  1200     44.0    10   18.6   9.7   20.6         0  1373    .250    10.43   660
  5  1200     62.0    14   16.5  10.9   20.7         0  1372    .100    10.43  1012
  6  1200    123.0    28   10.4  16.1   20.2         0  1671    .070    10.66  2075
  7  1200    185.0    42    4.0  22.6   19.5         0  1148    .100    11.13  1987
  8  1200    202.0    46    2.0  24.5   18.9         0  1082    .100    11.13  2350
  9  1200    226.0    52    1.6  26.7   17.0         0  1040    .550    12.22  2450
 10  1200    246.0    56     .3  34.1   13.9         0   228   5.240    10.09   660
 11   600      0.0     0   19.3   3.8   16.6         0  2520   2.870    10.09    33
 12  1200      0.0     0   23.0   3.8   32.0         0 26607    .150     3.45     9
 13  2300    256.0   112    1.3  66.3   13.4         0  1196   4.300    11.92   565
 14  2300    236.0   103    2.1  59.9   14.0         0   612   2.920    12.71  1112
 15  2300    210.0    92    2.3  52.3   15.7         0   150    .770    13.18  1250
 16  2300    192.0    84    2.5  48.7   16.7         0   126    .310    12.59  1237
 17  2300    128.0    56   10.3  32.4   19.5         0   738    .150    10.78  3000
 18  2300     64.0    28   14.9  23.2   20.7         0   438    .100    10.25  1475
 19  2300     46.0    20   16.3  20.6   21.7         0   321    .070     9.64   900
 20  2300     20.0     9   18.0  17.1   22.4         0   283    .070     9.37   495
 21  2300      5.0     2   19.1  14.8   23.5         0  1060    .100     8.75   280
 22   600      0.0     0   19.0   3.7   17.5         0  2686   2.400     9.25    37
 23  2300      0.0     0   24.4   4.0   46.5         0 43044    .020      .09     7
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO      NO2   FAC.      HP  ALDE.       HC       CO     NO2
-----------------------------------------------------------------------------------
  1   0.0    21.4     474      1.3   .070     0.0     I         R        R       R
  2   0.0    14.1     180      5.8   .060      .1   0.0     12.35    157.8     5.0
  3   0.0    36.1     411     16.3   .060      .3   0.0      7.89     89.9     3.6
  4   0.0    55.9     205     89.1   .050      .5   0.0      5.56     20.4     8.9
  5   0.0    63.6      94    155.8   .030      .4   0.0      4.49      6.6    11.0
  6   0.0   112.0      95    461.7   .060     1.7   0.0      3.98      3.4    16.4
  7   0.0   103.7     183    596.3 0.000     0.0   0.0      2.45      4.3    14.1
  8   0.0   106.0     198    764.7   .040     1.8   0.0      2.30      4.3    16.6
  9   0.0    97.8    1045    765.2 0.000     0.0   0.0      1.89     20.2    14.8
 10   0.0    23.0   10664    220.8 0.000     0.0   0.0       .41    189.7     3.9
 11   0.0    32.9     756      1.4   .070     0.0     I         R        R       R
 12   0.0   732.5      83       .8   .120     0.0     I         R        R       R
 13   0.0   220.1   15987    345.2   .025     2.8   0.0      1.96    142.6     3.1
 14   0.0   106.0   10214    639.6   .055     5.7   0.0      1.03     98.8     6.2
 15   0.0    25.4    2642    705.0   .035     3.2   0.0       .28     28.7     7.7
 16   0.0    21.5    1071    702.9   .060     5.0   0.0       .26     12.7     8.4
 17   0.0    98.5     405   1330.3   .060     3.4   0.0      1.76      7.2    23.7
 18   0.0    44.4     205    495.8 0.000     0.0   0.0      1.58      7.3    17.7
 19   0.0    30.8     136    286.6   .065     1.3   0.0      1.53      6.7    14.2
 20   0.0    23.2     116    134.6 0.000     0.0   0.0      2.64     13.2    15.4
 21   0.0    79.5     151     69.7 0.000     0.0   0.0     36.29     69.2    31.8
 22   0.0    37.8     683      1.7   .080     0.0     I         R        R       R
 23   0.0  1769.2      17      1.0   .060     0.0     I         R        R       R

CYCLE COMPOSITE    HC      9.189    GRAM/BHP HR
                   CO     52.054    GRAM/BHP HR
                   NO2    10.613    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .695      LB/BHP HR
```

ENGINE 1-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

TABULAR DATA

(AFTER CATALYST)

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-24-72 RUN-2 ENG.1-3 72 VERSION 6 BTDC O-CATSTD TIM W/AIR AFTER
------------------------------------------------------------------------------------------
               DYNA.          MAN.  FUEL     A/F                    DRY CONCENTRATION
MODE SPEED     LOAD     HP    VAC.  LB/HR    RATIO    ALDE.     HC       CO        CO2      NO
------------------------------------------------------------------------------------------
  1   600       0.0      0    17.5    4.0    18.8       0      398     .050     11.36      39
  2  1200       5.0      1    19.8    6.6    21.2       0      349     .020      9.93      70
  3  1200      19.0      4    19.5    7.1    21.1       0      132     .020      9.93     109
  4  1200      42.0     10    18.3    8.5    20.7       0      224     .020     10.25     260
  5  1200      59.0     13    16.6   10.2    20.8       0      262     .020     10.09     450
  6  1200     118.0     27    10.0   16.0    19.9       0      374     .020     10.66    1100
  7  1200     177.0     40     2.3   23.2    18.2       0      288     .050     11.48    1387
  8  1200     194.0     44     1.9   24.6    17.4       0      286     .050     12.09    1612
  9  1200     217.0     50     1.6   27.9    15.3       0      282     .250     13.63    1262
 10  1200     236.0     54      .3   32.5    13.5       0     1086    2.920     12.59     650
 11   600       0.0      0    17.5    3.9    17.7       0      389     .250     11.92      53
 12  1200       0.0      0    22.1    4.2    27.0       0     5926     .050      7.00       8
 13  2300     242.0    106     1.3   66.9    12.4       0     2571    5.560     11.24     520
 14  2300     223.0     98     2.2   60.2    13.0       0     1811    3.980     12.22     913
 15  2300     198.0     87     2.4   54.3    14.2       0      359    1.590     13.48     838
 16  2300     182.0     80     2.5   52.1    15.3       0       37     .310     13.33     640
 17  2300     121.0     53    10.1   32.6    18.0       0      111     .020     11.60    1787
 18  2300      61.0     27    14.7   23.6    20.2       0       79     .020     10.25     630
 19  2300      44.0     19    15.7   21.8    20.7       0       72     .020      9.93     460
 20  2300      19.0      8    17.6   18.1    22.1       0       50     .020      9.14     215
 21  2300       5.0      2    18.7   15.8    23.2       0      297     .020      8.75     140
 22   600       0.0      0    17.7    4.1    19.4       0      304     .050      8.84      52
 23  2300       0.0      0    23.8    4.5    40.5       0      718     .180      4.64       7
------------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.       HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1    0.0     6.3       16      2.1   .070      0.0      I        R        R        R
  2    0.0    10.5       12      7.0   .060       .1    0.0     9.17     10.6      6.1
  3    0.0     4.3       13     11.7   .060       .3    0.0      .99      3.0      2.7
  4    0.0     8.4       15     32.3   .050       .5    0.0      .88      1.6      3.4
  5    0.0    12.0       18     68.2   .030       .4    0.0      .89      1.4      5.1
  6    0.0    25.3       27    247.3   .060      1.6    0.0      .94      1.0      9.2
  7    0.0    26.2       92    419.2  0.000      0.0    0.0      .65      2.3     10.4
  8    0.0    26.3       93    490.9   .040      1.8    0.0      .59      2.1     11.1
  9    0.0    25.7      460    381.2  0.000      0.0    0.0      .52      9.3      7.7
 10    0.0   102.5     5567    203.7  0.000      0.0    0.0     1.90    103.2      3.8
 11    0.0     5.6       73      2.5   .070      0.0      I        R        R        R
 12    0.0   147.7       25       .6   .120      0.0      I        R        R        R
 13    0.0   457.4    19981    307.1   .025      2.6    0.0     4.32    188.5      2.9
 14    0.0   301.9    13402    505.0   .055      5.4    0.0     3.09    137.2      5.2
 15    0.0    58.5     5237    453.4   .035      3.0    0.0      .67     60.4      5.2
 16    0.0     6.5     1085    368.0   .060      4.8    0.0      .08     13.6      4.6
 17    0.0    14.1       51    754.5   .060      3.2    0.0      .27      1.0     14.2
 18    0.0     8.3       42    217.9  0.000      0.0    0.0      .31      1.6      8.2
 19    0.0     7.2       40    151.7   .065      1.3    0.0      .37      2.1      7.9
 20    0.0     4.5       36     63.9  0.000      0.0    0.0      .54      4.3      7.7
 21    0.0    24.2       33     37.9  0.000      0.0    0.0    11.06     15.0     17.3
 22    0.0     6.3       21      3.6   .080      0.0      I        R        R        R
 23    0.0    30.0      152      1.0   .060      0.0      I        R        R        R

CYCLE COMPOSITE    HC       2.287    GRAM/BHP HR
                   CO      61.065    GRAM/BHP HR
                   NO2      6.776    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .745      LB/BHP HR
```

```
                       PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-25-72 RUN-1        ENG.1-3    1972 VER A O-CAT W/AIR 6 BTDC
---------------------------------------------------------------------------------
             DYNA.          MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED   LOAD     HP   VAC. LB/HR   RATIO    ALDE.    HC       CO       CO2      NO
---------------------------------------------------------------------------------
   1   600     0.0     0  17.5    3.9    18.8        0    421    .050    11.72     47
   2  1200     5.0     1  19.9    7.6    21.1        0     93    .050    10.25     60
   3  1200    18.0     4  19.2    8.2    20.8        0    170    .050    10.55    127
   4  1200    41.0     9  17.8    9.4    20.5        0    225    .050    10.66    305
   5  1200    58.0    13  16.0   10.9    20.7        0    242    .050    10.55    410
   6  1200   115.0    26  10.2   15.3    20.0        0    353    .050    11.01    925
   7  1200   173.0    40   2.1   24.2    18.2        0    258    .070    11.92   1162
   8  1200   189.0    43   1.8   25.8    17.2        0    238    .070    12.71   1425
   9  1200   212.0    48   1.7   27.5    16.0        0    240    .100    14.05   1375
  10  1200   230.0    53    .3   33.4    13.8        0   1036   3.240    13.06    605
  11   600     0.0     0  17.6    4.0    18.3        0    413    .050    12.47     51
  12  1200     0.0     0  22.0    4.3    30.6        0   7929    .050     7.09      8
  13  2300   242.0   106   1.3   66.4    12.6        0   2315   5.560    11.48    555
  14  2300   223.0    98   1.7   59.1    13.4        0   1255   3.610    12.71   1012
  15  2300   198.0    87   2.3   54.5    14.3        0    371   1.800    13.63    863
  16  2300   182.0    80   2.4   51.7    15.1        0     45    .520    14.05    640
  17  2300   121.0    53  10.1   32.7    17.7        0     93    .020    12.22   1875
  18  2300    61.0    27  14.6   24.0    19.7        0     81    .020    10.89    720
  19  2300    44.0    19  15.9   21.3    20.3        0     69    .020    10.25    465
  20  2300    19.0     8  17.5   18.1    21.2        0     51    .020     9.78    235
  21  2300     5.0     2  18.8   15.4    22.6        0    433    .020     8.93    144
  22   600     0.0     0  17.5    4.0    18.7        0    305    .020    11.60     52
  23  2300     0.0     0  23.8    4.4    44.0        0  12546    .180     4.74      4
---------------------------------------------------------------------------------
         CALCULATED GRAM/HR         WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.      HP  ALDE.     HC      CO     NO2
---------------------------------------------------------------------------------
   1   0.0    6.3      15     2.3  .070     0.0      I      R       R       R
   2   0.0    3.1      34     6.7  .060      .1    0.0   2.73    29.6     5.8
   3   0.0    6.0      35    14.8  .060      .2    0.0   1.45     8.6     3.6
   4   0.0    9.0      40    40.2  .050      .5    0.0    .96     4.3     4.3
   5   0.0   11.2      47    63.3  .030      .4    0.0    .85     3.5     4.8
   6   0.0   22.1      63   192.1  .060     1.6    0.0    .84     2.4     7.3
   7   0.0   23.6     129   352.6 0.000     0.0    0.0    .60     3.3     8.9
   8   0.0   21.7     129   432.4  .040     1.7    0.0    .50     3.0    10.0
   9   0.0   21.1     178   401.7 0.000     0.0    0.0    .44     3.7     8.3
  10   0.0   95.7    6045   185.5 0.000     0.0    0.0   1.82   115.0     3.5
  11   0.0    6.0      15     2.5  .070     0.0      I      R       R       R
  12   0.0  194.9      25      .7  .120     0.0      I      R       R       R
  13   0.0  403.7   19586   321.3  .025     2.6    0.0   3.81   184.8     3.0
  14   0.0  204.5   11887   548.0  .055     5.4    0.0   2.09   121.7     5.6
  15   0.0   59.4    5811   457.7  .035     3.0    0.0    .68    67.0     5.3
  16   0.0    7.2    1690   341.9  .060     4.8    0.0    .09    21.2     4.3
  17   0.0   11.3      49   753.8  .060     3.2    0.0    .21      .9    14.2
  18   0.0    8.1      40   238.3 0.000     0.0    0.0    .30     1.5     8.9
  19   0.0    6.5      38   145.1  .065     1.3    0.0    .34     2.0     7.5
  20   0.0    4.3      34    65.3 0.000     0.0    0.0    .51     4.1     7.9
  21   0.0   33.6      31    37.1 0.000     0.0    0.0  15.36    14.3    16.9
  22   0.0    4.7       6     2.7  .080     0.0      I      R       R       R
  23   0.0  405.5     118      .4  .060     0.0      I      R       R       R

CYCLE COMPOSITE     HC       3.128    GRAM/BHP HR
                    CO      59.899    GRAM/BHP HR
                    NO2      6.627    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .752      LB/BHP HR
```

```
                            PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-25-72 RUN-3   ENG.1-3   1972 VER A O-CATW/AIR MODI TDC
-------------------------------------------------------------------------------------------
                   DYNA.        MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED         LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
-------------------------------------------------------------------------------------------
   1   600          0.0     0   16.7   3.8    19.1        0     349    .050     11.48      57
   2  1200          4.0     1   20.0   7.6    22.6        0     136    .050      9.37      54
   3  1200         16.0     4   19.1   8.5    22.1        0     137    .050      9.64     135
   4  1200         37.0     8   17.5   9.6    21.6        0     147    .050      9.93     260
   5  1200         52.0    12   15.9  10.7    21.4        0     173    .050      9.93     350
   6  1200        103.0    24   10.4  15.6    20.3        0     242    .050     10.66     775
   7  1200        155.0    35    1.8  23.5    18.5        0     155    .050     11.72     963
   8  1200        169.0    39    1.7  25.0    17.7        0     139    .050     12.22    1213
   9  1200        190.0    43    1.6  27.4    16.2        0     113    .070     13.18    1175
  10  1200        260.0    59     .3  32.8    13.5        0     675   2.780     12.71     480
  11   600          0.0     0   16.8   3.9    18.3        0     349    .070     11.72      65
  12  1200          0.0     0   22.0   4.2    27.2        0    4342    .050      7.37      16
  13  2300        222.0    97    1.3  65.7    13.6        0     436   3.100     12.71     380
  14  2300        204.0    89    2.1  58.3    14.7        0      53    .640     13.77     790
  15  2300        182.0    80    2.3  54.2    15.9        0      54    .050     13.06     650
  16  2300        167.0    73    2.4  51.5    16.5        0      53    .050     12.71     550
  17  2300        111.0    49   10.5  32.0    19.2        0     108    .020     10.78    1400
  18  2300         56.0    25   14.9  23.5    20.8        0      82    .020      9.64     535
  19  2300         40.0    18   15.7  21.6    20.8        0      70    .020      9.37     400
  20  2300         18.0     8   17.2  18.6    21.1        0      53    .020      8.93     235
  21  2300          4.0     2   18.3  16.5    21.5        0      85    .020      8.68     160
  22   600          0.0     0   16.7   3.8    17.6        0     331    .050     11.24      56
  23  2300          0.0     0   23.7   4.6    33.9        0     303    .150      4.64       4
-------------------------------------------------------------------------------------------
            CALCULATED GRAM/HR             WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.         HC       CO      NO2   FAC.       HP   ALDE.       HC       CO      NO2
-------------------------------------------------------------------------------------------
   1   0.0        5.2       15      2.8   .070      0.0       I        R        R        R
   2   0.0        5.0       37      6.6   .060       .1     0.0     5.43     40.4      7.2
   3   0.0        5.5       40     17.8   .060       .2     0.0     1.49     11.0      4.9
   4   0.0        6.4       44     37.6   .050       .4     0.0      .76      5.2      4.4
   5   0.0        8.4       49     56.4   .030       .4     0.0      .71      4.1      4.7
   6   0.0       15.9       67    169.6   .060      1.4     0.0      .68      2.8      7.2
   7   0.0       14.0       91    289.2  0.000      0.0     0.0      .40      2.6      8.2
   8   0.0       12.8       93    371.8   .040      1.5     0.0      .33      2.4      9.6
   9   0.0       10.6      133    365.6  0.000      0.0     0.0      .24      3.1      8.4
  10   0.0       64.5     5370    152.4  0.000      0.0     0.0     1.09     90.4      2.6
  11   0.0        5.2       21      3.2   .070      0.0       I        R        R        R
  12   0.0      105.3       24      1.3   .120      0.0       I        R        R        R
  13   0.0       81.9    11771    237.2   .025      2.4     0.0      .84    121.1      2.4
  14   0.0        4.8     2372    481.2   .055      4.9     0.0      .11     26.5      5.4
  15   0.0       10.1      189    404.5   .035      2.8     0.0      .13      2.4      5.1
  16   0.0        9.6      185    334.2   .060      4.4     0.0      .13      2.5      4.6
  17   0.0       14.5       54    624.1   .060      2.9     0.0      .30      1.1     12.8
  18   0.0        9.0       45    195.8  0.000      0.0     0.0      .37      1.0      8.0
  19   0.0        7.3       42    138.5   .065      1.1     0.0      .41      2.4      7.9
  20   0.0        5.0       38     73.5  0.000      0.0     0.0      .63      4.8      9.3
  21   0.0        7.3       35     45.7  0.000      0.0     0.0     4.19     19.8     26.1
  22   0.0        5.0       15      2.8   .080      0.0       I        R        R        R
  23   0.0       13.1      131       .6   .060      0.0       I        R        R        R

CYCLE COMPOSITE     HC        .978   GRAM/BHP HR
                    CO      21.208   GRAM/BHP HR
                    NO2      6.374   GRAM/BHP HR
                    ALDE     0.000   GRAM/BHP HR
                    BSFC      .818     LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-25-72 RUN-2    ENG.1-3   1972 VER A O-CAT W/AIR MODI 6 BTDC
-----------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO    ALDE.    HC        CO       CO2     NO
-----------------------------------------------------------------------------------
  1   600      0.0     0  17.7    4.1   19.2        0   420     .050    11.36     50
  2  1200      4.0     1  20.0    7.2   22.0        0   112     .020     9.78     64
  3  1200     18.0     4  19.4    8.1   22.0        0   156     .020     9.64    142
  4  1200     40.0     9  18.2    9.2   21.5        0   200     .020    10.09    320
  5  1200     56.0    13  16.2   10.8   21.4        0   219     .020    10.09    430
  6  1200    111.0    25  10.8   15.7   20.4        0   302     .020    10.66   1037
  7  1200    167.0    38   2.7   23.6   18.6        0   222     .050    11.72   1125
  8  1200    182.0    42   1.9   24.5   18.2        0   228     .050    11.92   1287
  9  1200    204.0    47   1.7   26.7   16.5        0   213     .070    13.06   1500
 10  1200    222.0    51    .3   33.7   13.7        0   820    2.870    12.94    600
 11   600      0.0     0  17.6    4.0   18.2        0   328     .050    11.92     54
 12  1200      0.0     0  22.8    4.4   27.1        0  5392     .050     7.28     23
 13  2300    236.0   103   1.3   66.7   13.5        0   476    3.150    12.71    425
 14  2300    217.0    95   1.9   66.4   13.1        0   621    4.120    12.09    345
 15  2300    194.0    85   2.4   53.3   15.8        0    37     .070    13.48    775
 16  2300    177.0    78   2.5   50.2   16.8        0    40     .020    12.47    625
 17  2300    118.0    52  10.4   32.0   18.9        0   120     .020    11.13   1762
 18  2300     59.0    26  14.8   23.0   20.8        0    88     .020     9.93    685
 19  2300     42.0    18  16.0   21.3   21.6        0    75     .020     9.37    475
 20  2300     19.0     8  17.6   18.3   22.8        0    57     .020     8.93    245
 21  2300      5.0     2  18.5   16.0   23.8        0   205     .020     8.54    159
 22   600      0.0     0  17.5    4.0   18.9        0   320     .020    11.01     53
 23  2300      0.0     0  23.8    4.5   45.2        0   936     .180     4.11      4
-----------------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
-----------------------------------------------------------------------------------
  1   0.0     6.8      16     2.7  .070      0.0      I       R        R       R
  2   0.0     3.7      13     7.1  .060       .1    0.0    4.09     14.7     7.7
  3   0.0     5.9      15    17.9  .060       .2    0.0    1.44      3.7     4.4
  4   0.0     8.2      17    43.8  .050       .5    0.0     .90      1.8     4.8
  5   0.0    10.6      20    69.0  .030       .4    0.0     .83      1.5     5.4
  6   0.0    20.1      27   228.9  .060      1.5    0.0     .79      1.1     9.0
  7   0.0    20.1      92   339.1 0.000      0.0    0.0     .53      2.4     8.9
  8   0.0    21.1      94   395.9  .040      1.7    0.0     .51      2.3     9.5
  9   0.0    19.6     130   458.6 0.000      0.0    0.0     .42      2.8     9.8
 10   0.0    78.8    5576   191.6 0.000      0.0    0.0    1.55    109.9     3.8
 11   0.0     5.0      15     2.7  .070      0.0      I       R        R       R
 12   0.0   136.8      26     1.9  .120      0.0      I       R        R       R
 13   0.0    90.5   12102   268.4  .025      2.6    0.0     .88    117.1     2.6
 14   0.0   114.9   15404   212.0  .055      5.2    0.0    1.21    162.1     2.2
 15   0.0     6.6     252   459.0  .035      3.0    0.0     .08      3.0     5.4
 16   0.0     7.3      74   378.2  .060      4.7    0.0     .09       .9     4.9
 17   0.0    15.6      53   760.7  .060      3.1    0.0     .30      1.0    14.7
 18   0.0     9.3      42   238.2 0.000      0.0    0.0     .36      1.6     9.2
 19   0.0     7.7      42   162.1  .065      1.2    0.0     .42      2.3     8.8
 20   0.0     5.3      37    75.4 0.000      0.0    0.0     .64      4.5     9.1
 21   0.0    17.3      34    44.6 0.000      0.0    0.0    7.92     15.6    20.4
 22   0.0     5.2       7     2.9  .080      0.0      I       R        R       R
 23   0.0    43.6     169      .6  .060      0.0      I       R        R       R

CYCLE COMPOSITE     HC      1.427   GRAM/BHP HR
                    CO     49.603   GRAM/BHP HR
                    NO2     6.215   GRAM/BHP HR
                    ALDE    0.000   GRAM/BHP HR
                    BSFC     .782     LB/BHP HR
```

```
                   PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-28-72 RUN-1 ENG.1-3 72 VERSION  15 BTDC  600 RPM A W/AIR MOD O-CAT
-----------------------------------------------------------------------------
            DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED   LOAD   HP   VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2     NO
-----------------------------------------------------------------------------
  1   600     0.0    0   20.2   4.0   19.1      0     325   .050   11.72     34
  2  1200     5.0    1   20.9   7.1   22.7      0     118   .020    9.64     60
  3  1200    20.0    5   19.9   8.5   21.5      0     184   .020   10.25    148
  4  1200    44.0   10   18.6   9.7   21.1      0     291   .020   10.55    605
  5  1200    62.0   14   16.5  10.9   21.3      0     310   .020   10.25    925
  6  1200   123.0   28   10.4  16.1   20.5      0     396   .050   10.78   1863
  7  1200   185.0   42    4.0  22.6   19.4      0     332   .050   11.36   1900
  8  1200   202.0   46    2.0  24.5   19.0      0     382   .050   11.48   2113
  9  1200   226.0   52    1.6  26.7   17.1      0     446   .070   12.47   2250
 10  1200   246.0   56     .3  34.1   13.7      0    1750  3.470   12.47    810
 11   600     0.0    0   19.3   3.8   17.4      0     417   .050   12.71     41
 12  1200     0.0    0   23.0   3.8   30.7      0    4770   .020    6.47      9
 13  2300   256.0  112    1.3  66.3   13.7      0     587  3.330   12.94    615
 14  2300   236.0  103    2.1  59.9   14.5      0     198  1.450   13.77   1313
 15  2300   210.0   92    2.3  52.3   16.6      0      40   .050   12.94   1275
 16  2300   192.0   84    2.5  48.7   17.7      0      40   .020   12.09   1200
 17  2300   128.0   56   10.3  32.4   19.1      0     229   .020   11.01   2900
 18  2300    64.0   28   14.9  23.2   21.0      0     151   .020   10.09   1225
 19  2300    46.0   20   16.3  20.6   22.1      0     114   .020    9.64    738
 20  2300    20.0    9   18.0  17.1   23.3      0     601   .020    8.93    400
 21  2300     5.0    2   19.1  14.8   24.5      0    1079   .020    8.54    230
 22   600     0.0    0   19.0   3.7   18.0      0     394   .020   11.84     48
 23  2300     0.0    0   24.4   4.0   51.6      0    3485   .130    3.40     18
-----------------------------------------------------------------------------
         CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC     CO     NO2  FAC.      HP  ALDE.     HC      CO     NO2
-----------------------------------------------------------------------------
  1   0.0     5.0     16     1.7  .070     0.0     I       R       R       R
  2   0.0     3.9     13     6.6  .060      .1   0.0    3.43    11.8     5.8
  3   0.0     6.9     15    18.4  .060      .3   0.0    1.51     3.3     4.0
  4   0.0    12.1     17    83.4  .050      .5   0.0    1.20     1.7     8.3
  5   0.0    14.9     19   147.4  .030      .4   0.0    1.05     1.4    10.4
  6   0.0    26.6     68   415.6  .060     1.7   0.0     .95     2.4    14.8
  7   0.0    29.7     90   565.1 0.000     0.0   0.0     .70     2.1    13.4
  8   0.0    36.7     97   673.9  .040     1.8   0.0     .79     2.1    14.6
  9   0.0    43.0    136   718.9 0.000     0.0   0.0     .83     2.6    13.9
 10   0.0   168.0   6728   258.1 0.000     0.0   0.0    2.99   119.7     4.6
 11   0.0     5.6     14     1.8  .070     0.0     I       R       R       R
 12   0.0   118.0     10      .7  .120     0.0     I       R       R       R
 13   0.0   108.1  12389   376.1  .025     2.8   0.0     .96   110.5     3.4
 14   0.0    33.6   5222   777.2  .055     5.7   0.0     .32    50.5     7.5
 15   0.0     7.4    184   772.8  .035     3.2   0.0     .08     2.0     8.4
 16   0.0     7.3     74   726.5  .060     5.0   0.0     .09      .9     8.6
 17   0.0    30.5     54  1280.2  .060     3.4   0.0     .54     1.0    22.8
 18   0.0    15.7     42   422.7 0.000     0.0   0.0     .56     1.5    15.1
 19   0.0    11.1     39   236.7  .065     1.3   0.0     .55     1.9    11.8
 20   0.0    51.7     35   114.3 0.000     0.0   0.0    5.91     4.0    13.1
 21   0.0    83.6     31    59.1 0.000     0.0   0.0   38.17    14.3    27.0
 22   0.0     5.6      6     2.2  .080     0.0     I       R       R       R
 23   0.0   163.0    123     2.8  .060     0.0     I       R       R       R

CYCLE COMPOSITE    HC      1.437    GRAM/BHP HR
                   CO     24.241    GRAM/BHP HR
                   NO2    10.567    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .695      LB/BHP HR
```

ENGINE 1-3

EFFECT OF OXIDATION CATALYST ON EMISSIONS

GRAPHED RESULTS

(AFTER CATALYST)

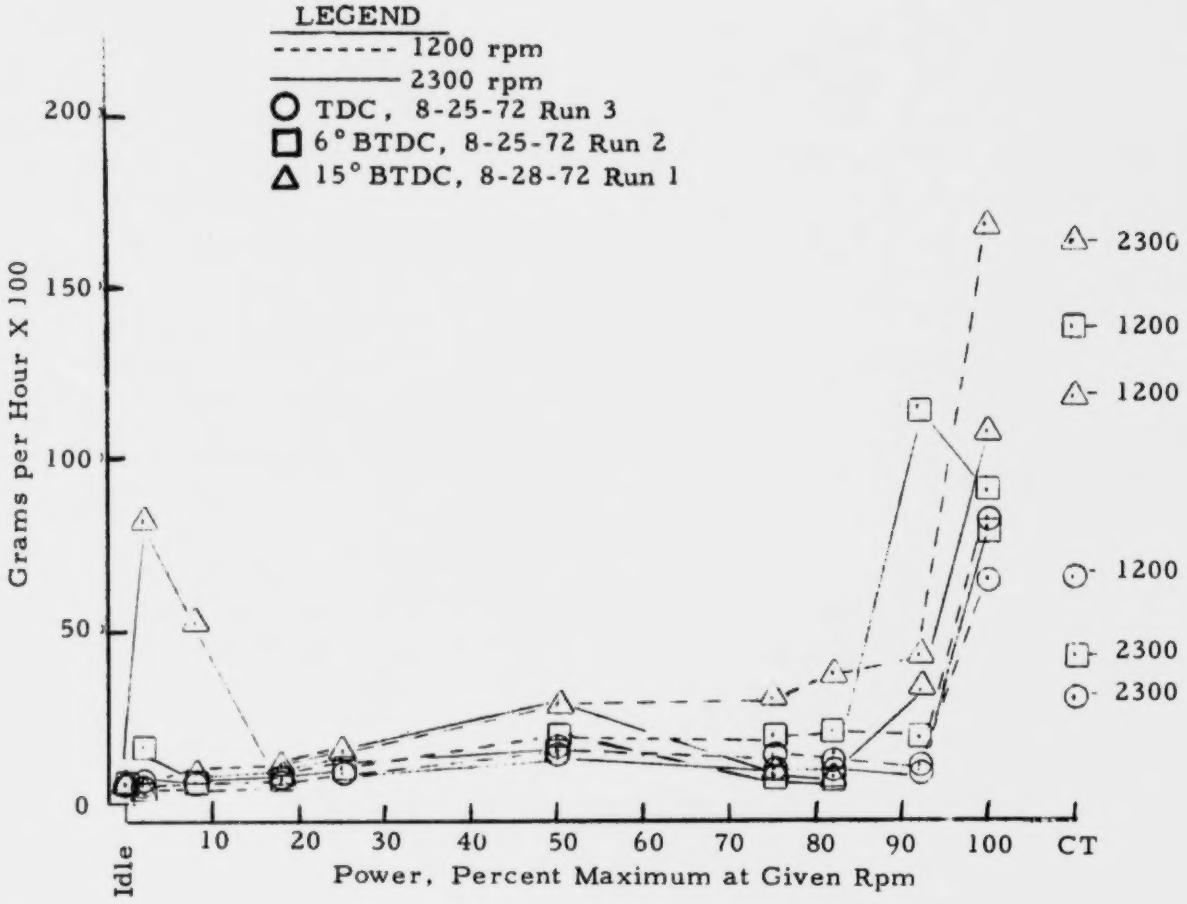


FIGURE U-1. EFFECT OF POWER ON HC EMISSION RATE AFTER CATALYST, MODIFIED AIR INJECTION ENGINE 1-3, 23 MODE TEST

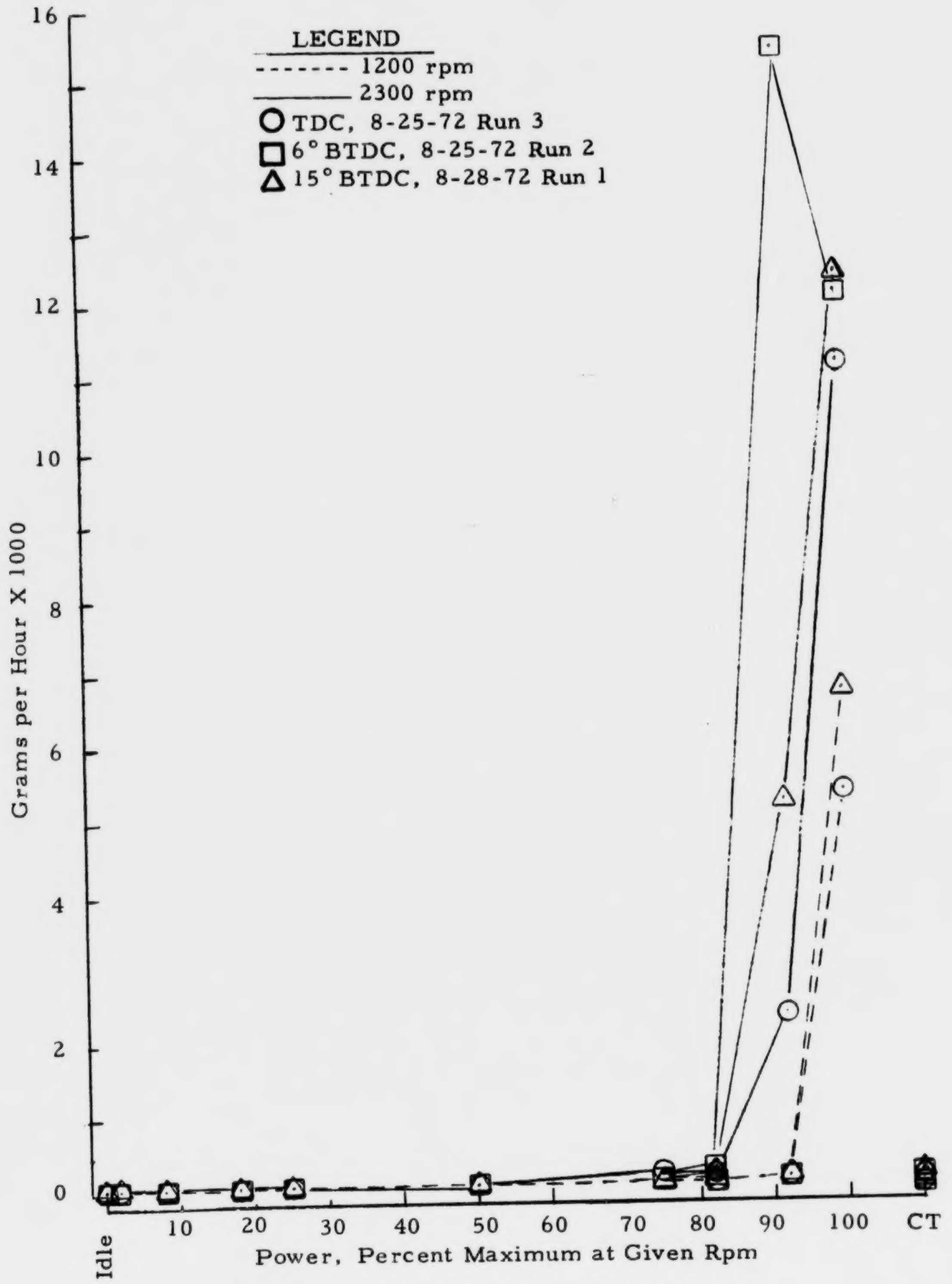


FIGURE U-2. EFFECT OF POWER ON CO EMISSIONS RATE AFTER CATALYST, MODIFIED AIR INJECTION ENGINE 1-3, 23 MODE TEST

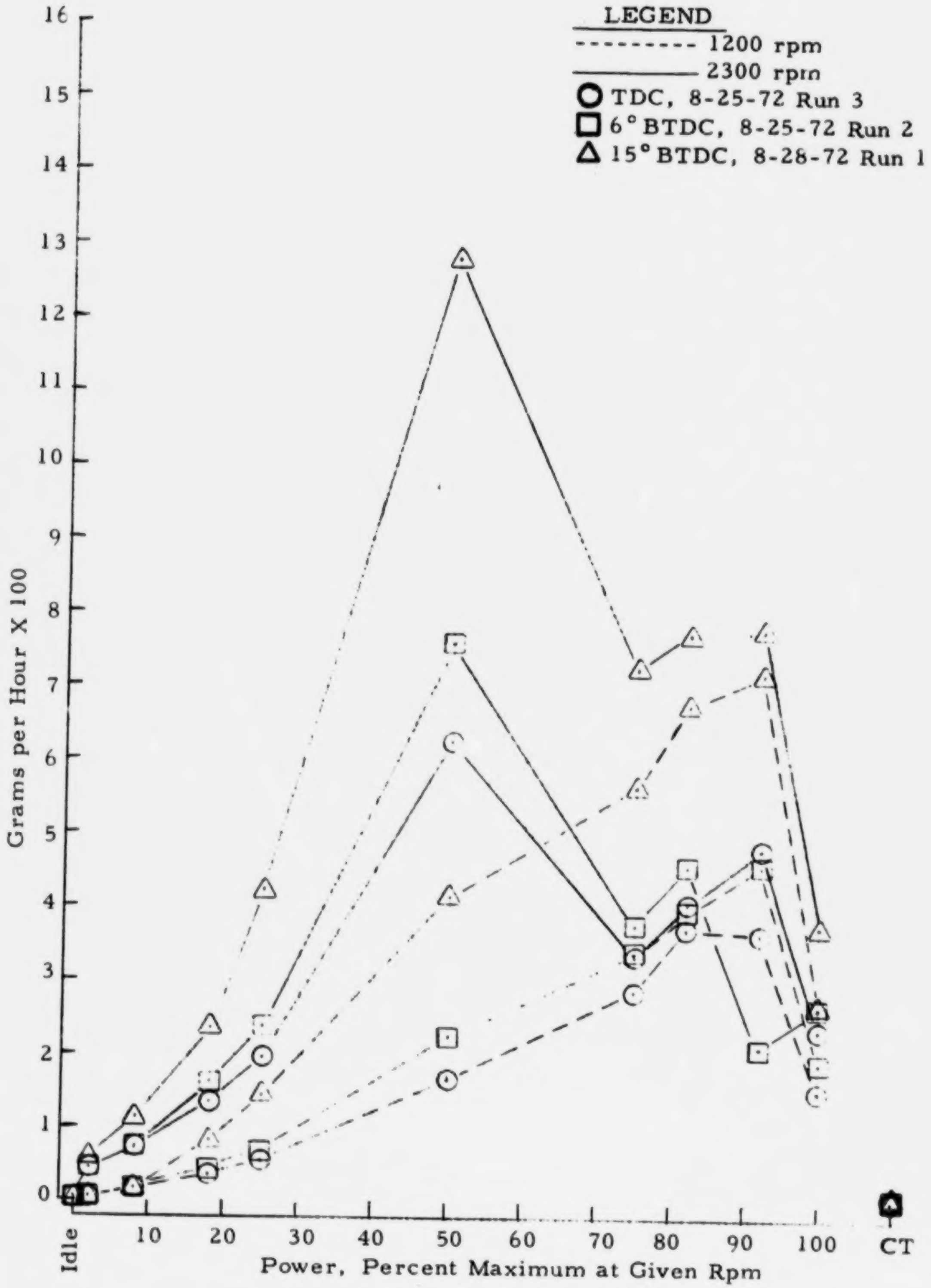


FIGURE U-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE AFTER CATALYST, MODIFIED AIR INJECTION ENGINE 1-3, 23 MODE TEST

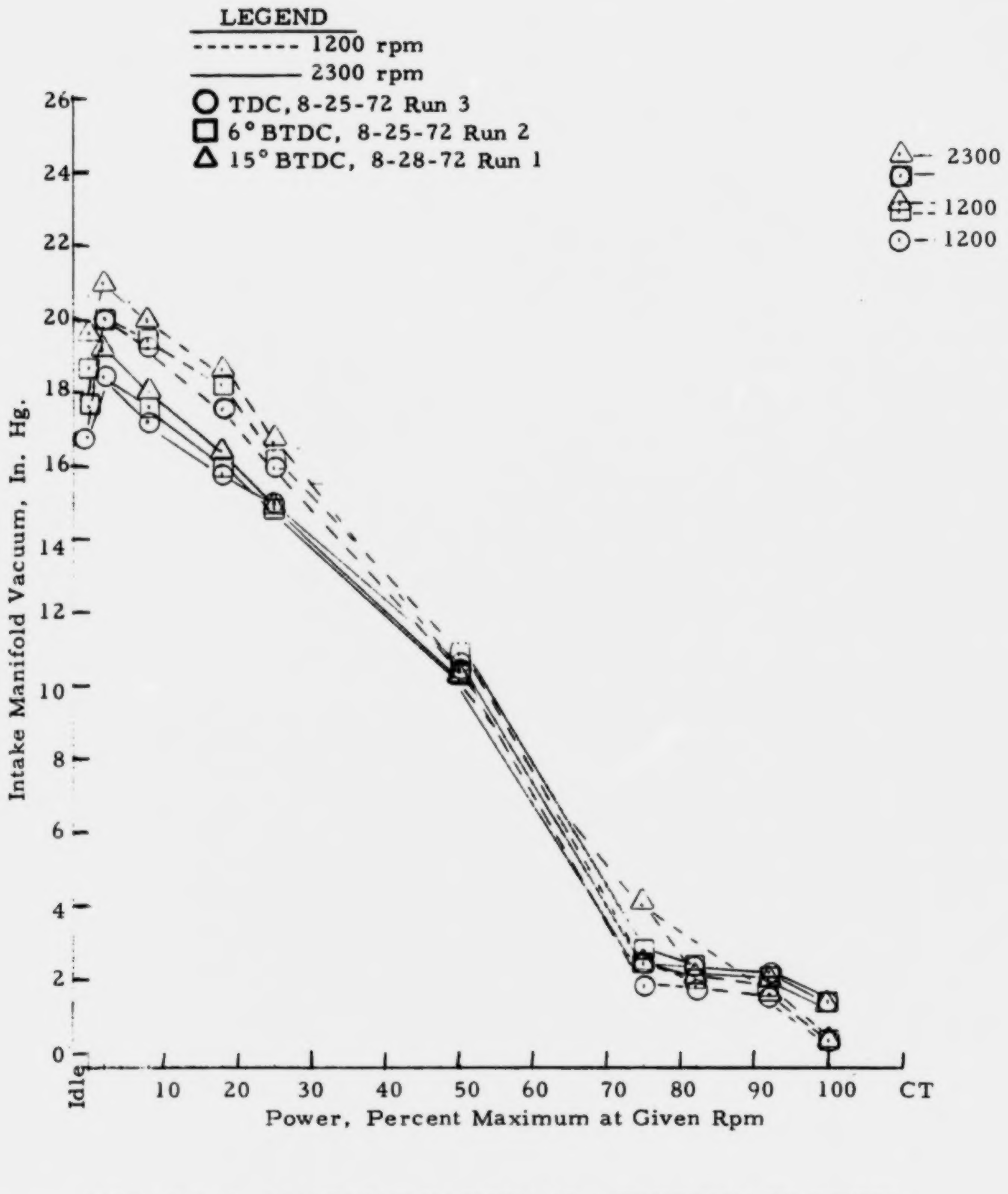


FIGURE U-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

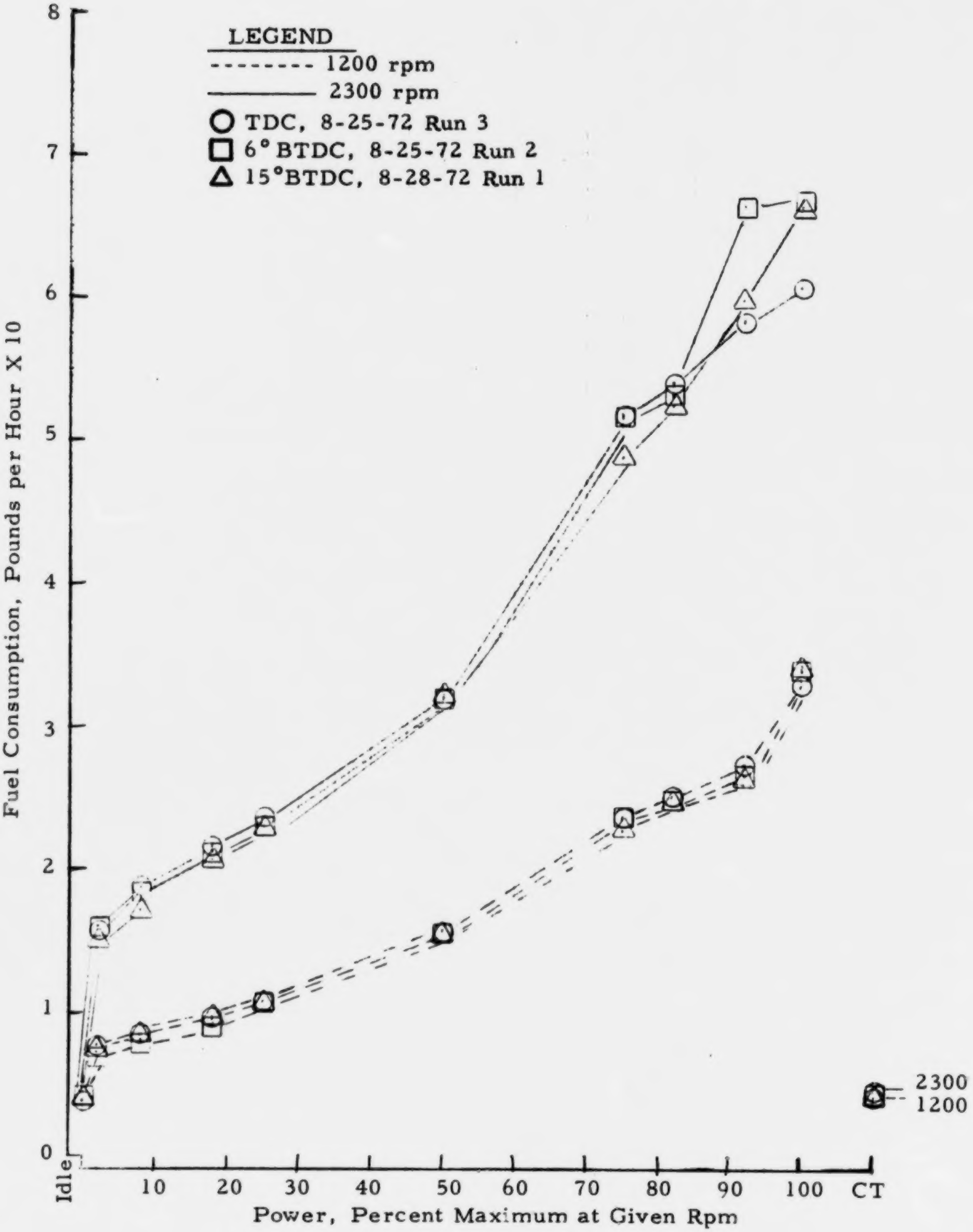


FIGURE U-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

APPENDIX V

ENGINE 1-3

EFFECT OF VARIOUS COMBINATIONS ON EMISSIONS

(23 MODE MASS RESULTS)

ENGINE 1-3

EFFECT OF VARIOUS COMBINATIONS ON EMISSIONS

TABULAR DATA

BEFORE CATALYST

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-31-72 RUN-1 ENG.1-3 72 VER. 15 BTDC AIR MODI.0.063 JETS O-Cat B
-------------------------------------------------------------------------------
               DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED     LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC        CO      CO2     NO
-------------------------------------------------------------------------------
   1   600      0.0      0   19.7    3.9    18.4        0   2498   1.840    10.09     26
   2  1200      5.0      1   20.9    7.0    22.5        0    377    .390     9.50     50
   3  1200     18.0      4   19.9    8.1    21.9        0    657    .520     9.78     99
   4  1200     41.0      9   18.7    9.2    21.4        0   1153    .350    10.25    450
   5  1200     58.0     13   17.6   10.4    20.0        0   1482    .890    10.55    680
   6  1200    115.0     26   13.1   15.8    17.8        0   2225   1.660    11.24   1475
   7  1200    173.0     40    8.4   22.6    16.5        0   2592   2.480    11.24   1175
   8  1200    189.0     43    7.3   23.8    16.7        0    254   2.480    11.24   1125
   9  1200    212.0     48    4.7   27.2    15.8        0   1644   2.360    12.09    820
  10  1200    230.0     53     .5   41.4    11.5        0   6168  10.800     6.91     73
  11   600      0.0      0   19.6    4.0    17.2        0   2488   2.690    10.09      6
  12  1200      0.0      0   23.0    4.0    31.1        0  31754    .180     3.35      5
  13  2300    248.0    109    1.8   76.7    11.8        0   3034   9.500     8.54    113
  14  2300    228.0    100    3.3   60.5    13.7        0   1128   4.740    11.60    840
  15  2300    203.0     89    5.2   55.2    13.8        0    754   4.070    12.34    680
  16  2300    186.0     81    6.8   50.8    14.0        0    609   3.420    12.71    700
  17  2300    124.0     54   11.3   38.7    15.3        0    176   1.230    13.33    565
  18  2300     62.0     27   16.2   26.2    16.9        0     71    .520    12.47    580
  19  2300     45.0     20   17.7   21.8    17.9        0    127    .470    11.92    480
  20  2300     20.0      9   19.4   17.0    19.2        0     93    .210    11.24    290
  21  2300      5.0      2   20.5   13.9    22.6        0    403    .180     9.37    151
  22   600      0.0      0   19.8    3.9    19.7        0   1828   1.550     9.37     35
  23  2300      0.0      0   24.1    4.2   245.1        0   4518    .100      .33      4
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR           WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO     NO2  FAC.       HP   ALDE.      HC       CO      NO2
-------------------------------------------------------------------------------
   1   0.0    36.3      540     1.3  .070      0.0       I       R        R        R
   2   0.0    12.0      252     5.3  .060       .1     0.0   10.54    220.6      4.6
   3   0.0    23.3      372    11.6  .060       .2     0.0    5.66     90.5      2.8
   4   0.0    44.9      275    58.2  .050       .5     0.0    4.79     29.4      6.2
   5   0.0    60.3      732    91.9  .030       .4     0.0    4.55     55.2      6.9
   6   0.0   121.5     1831   267.5  .060      1.6     0.0    4.63     69.7     10.2
   7   0.0   190.1     3674   286.1 0.000      0.0     0.0    4.81     92.9      7.2
   8   0.0    19.9     3935   293.3  .040      1.7     0.0     .46     91.1      6.8
   9   0.0   138.8     4025   229.8 0.000      0.0     0.0    2.86     83.1      4.7
  10   0.0   632.0    22354    25.0 0.000      0.0     0.0   12.03    425.4       .5
  11   0.0    34.6      757      .3  .070      0.0       I       R        R        R
  12   0.0   859.2       98      .5  .120      0.0       I       R        R        R
  13   0.0   575.4    36397    70.8  .025      2.7     0.0    5.30    335.1       .7
  14   0.0   188.2    15970   465.2  .055      5.5     0.0    1.88    159.9      4.7
  15   0.0   114.6    12487   342.9  .035      3.1     0.0    1.29    140.5      3.9
  16   0.0    86.7     9832   330.8  .060      4.9     0.0    1.06    120.7      4.1
  17   0.0    21.2     2992   225.9  .060      3.3     0.0     .39     55.1      4.2
  18   0.0     6.5      960   176.1 0.000      0.0     0.0     .24     35.4      6.5
  19   0.0    10.1      757   127.1  .065      1.3     0.0     .51     38.4      6.4
  20   0.0     6.3      285    64.8 0.000      0.0     0.0     .71     32.6      7.4
  21   0.0    26.5      239    33.0 0.000      0.0     0.0   12.09    109.2     15.1
  22   0.0    29.1      499     1.9  .080      0.0       I       R        R        R
  23   0.0   976.1      436     3.1  .060      0.0       I       R        R        R

CYCLE COMPOSITE    HC      8.684    GRAM/BHP HR
                   CO    140.829    GRAM/BHP HR
                   NO2     4.597    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .759      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-31-72 RUN-2 ENG.1-3 72 VER. B 6 BTDC 0.063 JETS MODI.AIR O-Cat
----------------------------------------------------------------------------------------------
              DYNA.        MAN. FUEL     A/F                 DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC        CO        CO2       NO
----------------------------------------------------------------------------------------------
   1   600     0.0     0   18.5   4.0    17.3        0   2614     2.640      9.50       33
   2  1200     4.0     1   20.2   7.2    22.6        0    261      .100      9.25       57
   3  1200    17.0     4   19.0   8.4    21.7        0    632      .180      9.50      177
   4  1200    38.0     9   18.0   9.5    21.1        0    853      .130      9.93      365
   5  1200    53.0    12   17.7  10.2    19.7        0    896      .640     10.09      350
   6  1200   105.0    24   13.8  15.2    17.5        0   1822     1.590     10.43      890
   7  1200   158.0    36    9.5  21.5    13.9        0  24697     2.360     10.55     1000
   8  1200   172.0    39    8.0  23.0    16.0        0   2016     2.400     10.55      888
   9  1200   193.0    44    4.9  27.4    15.1        0    520     1.630     12.47      570
  10  1200   210.0    48     .5  40.8    11.2        0   5246    10.140      7.09       76
  11   600     0.0     0   18.8   4.1    14.1        0   2015     2.320      9.25       41
  12  1200     0.0     0   22.2   4.1    30.6        0  25909      .250      3.68       13
  13  2300   236.0   103    1.8  76.0    11.6        0   2323     9.500      8.75      100
  14  2300   217.0    95    2.0  80.0    11.1        0   1252    10.800      7.56       64
  15  2300   194.0    85    4.3  57.2    13.5        0    690     4.260     11.92      545
  16  2300   177.0    78    6.5  51.9    13.7        0    607     3.700     12.09      510
  17  2300   118.0    52   11.8  37.6    15.1        0    130      .970     12.94      420
  18  2300    59.0    26   16.1  26.2    16.9        0     73      .420     12.34      395
  19  2300    42.0    18   17.5  22.5    17.9        0     94      .280     11.72      310
  20  2300    19.0     8   19.1  18.2    18.9        0     84      .070     11.01      222
  21  2300     5.0     2   20.2  15.4    20.7        0     60      .050      9.93      140
  22   600     0.0     0   18.5   4.0    18.5        0   1780     1.520      9.14       39
  23  2300     0.0     0   23.9   4.3    29.1        0  48612      .020       .23        5
----------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.      HC       CO      NO2
----------------------------------------------------------------------------------------------
   1   0.0   38.2      780     1.6   .070      0.0      I       R        R        R
   2   0.0    9.1       70     6.6   .060       .1    0.0    9.94     77.0      7.2
   3   0.0   24.7      142    23.0   .060       .2    0.0    6.36     36.6      5.9
   4   0.0   36.2      112    51.5   .050       .4    0.0    4.17     12.8      5.9
   5   0.0   38.3      553    49.7   .030       .4    0.0    3.16     45.7      4.1
   6   0.0  103.0     1815   167.0   .060      1.4    0.0    4.29     75.6      7.0
   7   0.0 1566.1     3023   210.5 0.000      0.0    0.0   43.38     83.7      5.8
   8   0.0  159.9     3846   233.7   .040      1.6    0.0    4.07     97.9      5.9
   9   0.0   45.7     2892   166.2 0.000      0.0    0.0    1.04     65.6      3.8
  10   0.0  546.8    21351    26.3 0.000      0.0    0.0   11.40    445.0       .5
  11   0.0   31.8      740     2.2   .070      0.0      I       R        R        R
  12   0.0  738.9      144     1.2   .120      0.0      I       R        R        R
  13   0.0  433.3    35794    61.9   .025      2.6    0.0    4.19    346.3       .6
  14   0.0  245.7    42827    42.0   .055      5.2    0.0    2.59    450.7       .4
  15   0.0  110.1    13741   288.9   .035      3.0    0.0    1.30    161.7      3.4
  16   0.0   90.2    11101   251.5   .060      4.7    0.0    1.16    143.2      3.2
  17   0.0   15.9     2400   170.8   .060      3.1    0.0     .31     46.4      3.3
  18   0.0    6.8      790   122.1 0.000      0.0    0.0     .26     30.6      4.7
  19   0.0    8.0      481    87.5   .065      1.2    0.0     .44     26.1      4.8
  20   0.0    6.2      105    55.0 0.000      0.0    0.0     .75     12.7      6.6
  21   0.0    4.2       71    32.5 0.000      0.0    0.0    1.92     32.3     14.8
  22   0.0   29.8      514     2.2   .080      0.0      I       R        R        R
  23   0.0 1855.1       15      .6   .060      0.0      I       R        R        R

CYCLE COMPOSITE      HC      10.908    GRAM/BHP HR
                     CO     211.348    GRAM/BHP HR
                     NO2      2.972    GRAM/BHP HR
                     ALDE     0.000    GRAM/BHP HR
                     BSFC      .853      LB/BHP HR
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
    8-28-72 RUN-2 ENG.1-3 72 VERS STD.TIME + JETS B W/AIR TAILORED EGR O-Cat
---------------------------------------------------------------------------------
                DYNA.        MAN. FUEL    A/F               DRY CONCENTRATION
MODE SPEED      LOAD   HP   VAC. LB/HR  RATIO    ALDE.    HC      CO     CO2    NO
---------------------------------------------------------------------------------
  1    600       0.0    0  18.1    4.1   18.3        0  2215  1.520   10.09    48
  2   1200       4.0    1  19.6    7.6   22.8        0   413   .150    9.25    59
  3   1200      18.0    4  19.1    8.1   22.4        0   582   .150    9.37   109
  4   1200      40.0    9  17.1    9.5   21.9        0   818   .130    9.64   200
  5   1200      56.0   13  15.0   11.3   21.9        0   872   .100    9.64   235
  6   1200     156.0   36   1.9   24.2   17.7        0   517   .280   11.84   565
  7   1200     167.0   38   1.8   25.4   16.7        0   443   .420   12.59   620
  8   1200     182.0   42   1.7   26.9   15.5        0   494   .930   12.94   465
  9   1200     204.0   47    .5   33.3   13.2        0  1917  5.560   10.09   205
 10   1200     222.0   51    .5   34.4   12.3        0  1699  6.710    7.65   400
 11    600       0.0    0  18.5    4.2   18.0        0  1839  2.020    9.64    39
 12   1200       0.0    0  22.3    4.3   32.1        0 27139   .210    3.45     8
 13   2300     220.0   96   1.7   62.1   13.6        0   939  3.930   11.72   285
 14   2300     202.0   88   1.7   60.5   13.2        0  1041  4.500   11.01   163
 15   2300     180.0   79   2.4   56.8   13.3        0   815  4.120   11.01   176
 16   2300     165.0   72   2.6   52.0   14.2        0   282  2.020   11.84   231
 17   2300     110.0   48   3.0   43.4   17.0        0  1987   .250   11.01   330
 18   2300      55.0   24  13.3   24.2   19.8        0   371   .100    8.84   280
 19   2300      40.0   18  15.0   21.4   19.5        0   249   .070    8.84   265
 20   2300      18.0    8  16.6   18.7   19.1        0   259   .070    8.60   180
 21   2300       4.0    2  17.8   16.2   19.1        0  1338   .100    8.48   104
 22    600       0.0    0  18.0    4.0   16.6        0  1951  1.340    9.03    44
 23   2300       0.0    0  24.0    4.4   22.8        0 46119   .050     .23     7
---------------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO    NO2  FAC.      HP  ALDE.      HC      CO     NO2
---------------------------------------------------------------------------------
  1    0.0   34.8     483    2.5  .070     0.0      I       R       R       R
  2    0.0   15.1     111    7.2  .060      .1    0.0   16.50   121.1     7.9
  3    0.0   22.3     116   13.8  .060      .2    0.0    5.43    28.3     3.4
  4    0.0   35.8     115   29.0  .050      .5    0.0    3.91    12.6     3.2
  5    0.0   45.5     105   40.7  .030      .4    0.0    3.55     8.2     3.2
  6    0.0   46.6     510  169.2  .060     2.1    0.0    1.31    14.3     4.7
  7    0.0   39.1     749  181.7 0.000     0.0    0.0    1.02    19.6     4.8
  8    0.0   43.3    1647  135.3  .040     1.7    0.0    1.04    39.6     3.3
  9    0.0  182.8   10709   64.9 0.000     0.0    0.0    3.92   229.7     1.4
 10    0.0  182.5   14556  142.6 0.000     0.0    0.0    3.60   287.0     2.8
 11    0.0   29.6     656    2.1  .070     0.0      I       R       R       R
 12    0.0  830.5     130     .8  .120     0.0      I       R       R       R
 13    0.0  168.0   14204  169.3  .025     2.4    0.0    1.74   147.4     1.8
 14    0.0  182.4   15976   94.8  .055     4.9    0.0    2.07   180.6     1.1
 15    0.0  138.1   14096   99.1  .035     2.8    0.0    1.75   178.8     1.3
 16    0.0   47.9    6930  130.4  .060     4.3    0.0     .66    95.9     1.8
 17    0.0  341.5     868  188.2  .060     2.9    0.0    7.09    18.0     3.9
 18    0.0   45.3     247  113.7 0.000     0.0    0.0    1.88    10.3     4.7
 19    0.0   27.0     154   95.6  .065     1.1    0.0    1.54     8.8     5.5
 20    0.0   25.3     138   58.3 0.000     0.0    0.0    3.21    17.5     7.4
 21    0.0  112.9     170   29.0 0.000     0.0    0.0   64.43    97.2    16.6
 22    0.0   33.5     465    2.5  .080     0.0      I       R       R       R
 23    0.0 1881.6      41     .9  .060     0.0      I       R       R       R

CYCLE COMPOSITE     HC     11.733   GRAM/BHP HR
                    CO    105.345   GRAM/BHP HR
                    NO2     2.503   GRAM/BHP HR
                    ALDE    0.000   GRAM/BHP HR
                    BSFC     .855     LB/BHP HR
```

```
                   PROJECT 11-2877-01  CONTROL TECHNOLOGY
8-30-72 RUN-1 ENG.1-3 72 VER. TDC STD JETS AIR MODI. EGR TAILORED B O-Cat
----------------------------------------------------------------------------------
                  DYNA.          MAN.  FUEL    A/F              DRY CONCENTRATION
MODE  SPEED       LOAD    HP    VAC.  LB/HR   RATIO   ALDE.     HC      CO      CO2      NO
----------------------------------------------------------------------------------
  1    600        0.0      0    17.4    4.4    19.0      0     1343   1.090     9.78     51
  2   1200        4.0      1    19.5    7.9    22.4      0      326    .150     9.37     61
  3   1200       16.0      4    19.0    8.4    22.0      0      431    .150     9.64     90
  4   1200       36.0      8    17.0    9.6    21.3      0      673    .130    10.09    230
  5   1200       51.0     12    15.7   11.3    21.5      0      678    .100     9.93    232
  6   1200      101.0     23     8.6   16.4    21.0      0     1007    .100    10.09    330
  7   1200      152.0     35     2.0   24.7    16.9      0      162    .210    12.59    460
  8   1200      166.0     38      .6   33.4    12.9      0     1522   5.450    11.13    106
  9   1200      186.0     42     2.0   26.3    16.3      0      154    .310    12.71   1212
 10   1200      202.0     46      .5   34.7    13.1      0     1205   4.880    11.13    265
 11    600        0.0      0    17.4    4.3    18.5      0     1437   1.160    10.25     52
 12   1200        0.0      0    21.7    4.6    28.2      0    27579    .210     4.19     18
 13   2300      205.0     90     1.8   63.6    13.1      0      954   4.840    11.36    200
 14   2300      184.0     83     1.7   62.7    13.0      0      957   4.740    11.01    175
 15   2300      168.0     74     1.7   60.0    12.9      0     1055   5.030    10.78     96
 16   2300      154.0     67     1.7   60.0    12.9      0     1152   5.080    10.09     80
 17   2300      103.0     45     2.9   44.9    16.8      0      610    .280    11.60    190
 18   2300       51.0     22     9.5   28.6    21.6      0     1409    .130     8.93    125
 19   2300       37.0     16    11.8   25.3    22.9      0      811    .100     8.75    107
 20   2300       16.0      7    14.8   21.3    22.7      0      595    .100     8.75    100
 21   2300        4.0      2    17.5   16.9    23.3      0      432    .070     8.60    127
 22    600        0.0      0    17.2    4.1    20.1      0     1158    .610     9.37     64
 23   2300        0.0      0    23.6    4.8    39.9      0    50631    .050      .23      4
----------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO     NO2   FAC.       HP  ALDE.      HC      CO     NO2
----------------------------------------------------------------------------------
  1   0.0     24.4     399     3.1   .070      0.0     I        R       R       R
  2   0.0     12.2     114     7.7   .060       .1    0.0   13.40   124.4     8.4
  3   0.0     16.7     117    11.6   .060       .2    0.0    4.57    32.1     3.2
  4   0.0     28.5     111    32.3   .050       .4    0.0    3.46    13.5     3.9
  5   0.0     34.4     103    39.2   .030       .3    0.0    2.95     8.8     3.4
  6   0.0     72.8     146    79.2   .060      1.4    0.0    3.15     6.3     3.4
  7   0.0     14.2     371   133.5  0.000      0.0    0.0     .41    10.7     3.8
  8   0.0    137.8    9968    31.9   .040      1.5    0.0    3.63   262.8      .8
  9   0.0     14.1     573   368.4  0.000      0.0    0.0     .33    13.5     8.7
 10   0.0    117.6    9619    85.8  0.000      0.0    0.0    2.55   208.4     1.9
 11   0.0     24.3     396     2.9   .070      0.0     I        R       R       R
 12   0.0    803.9     124     1.7   .120      0.0     I        R       R       R
 13   0.0    169.0   17309   117.6   .025      2.2    0.0    1.88   192.8     1.3
 14   0.0    171.7   17185   104.3   .055      4.6    0.0    2.07   207.6     1.3
 15   0.0    180.3   17375    54.5   .035      2.6    0.0    2.45   236.2      .7
 16   0.0    205.1   18271    47.3   .060      4.0    0.0    3.04   270.9      .7
 17   0.0    104.1     965   107.6   .060      2.7    0.0    2.31    21.4     2.4
 18   0.0    148.7     370    58.5  0.000      0.0    0.0    8.89    16.6     2.6
 19   0.0    104.3     260    45.9   .065      1.1    0.0    6.43    16.0     2.8
 20   0.0     64.5     219    36.0  0.000      0.0    0.0    9.21    31.3     5.1
 21   0.0     38.0     124    37.2  0.000      0.0    0.0   21.70    71.0    21.3
 22   0.0     21.3     227     3.9   .080      0.0     I        R       R       R
 23   0.0   2063.2      41      .5   .060      0.0     I        R       R       R

CYCLE COMPOSITE    HC     13.486    GRAM/BHP HR
                   CO    174.200    GRAM/BHP HR
                   NO2     1.601    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .993      LB/BHP HR
```

```
                PROJECT 11-2877-01  CONTROL TECHNOLOGY
8-29-72 RUN-1 ENG.1-3 72 VER. STD TIM.+JETS MODI.AIR+EGR TAILORED B O-Cat
-----------------------------------------------------------------------------
             DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED   LOAD    HP  VAC. LB/HR  RATIO   ALDE.     HC     CO      CO2     NO
-----------------------------------------------------------------------------
  1   600     0.0     0  17.8   4.0   17.5       0   2255  2.050   10.25    38
  2  1200     5.0     1  19.6   7.4   22.3       0    177   .150    9.50    50
  3  1200    18.0     4  18.9   8.3   21.9       0    622   .130    9.64   110
  4  1200    41.0     9  17.5   9.4   21.4       0    869   .100    9.93   260
  5  1200    58.0    13  16.1  10.6   21.5       0    983   .100    9.93   360
  6  1200   115.0    26   9.9  15.8   20.8       0   1337   .100   10.25  1063
  7  1200   173.0    40   2.6  23.6   19.2       0    702   .100   11.36  1363
  8  1200   189.0    43   2.0  25.5   17.1       0    939   .310   12.47  1125
  9  1200   212.0    48   1.0  29.3   13.0       0   1790  5.840   10.09   160
 10  1200   230.0    53    .5  34.8   13.1       0   1607  5.190   10.78   375
 11   600     0.0     0  18.4   4.1   18.1       0   1704  1.730    9.78    40
 12  1200     0.0     0  22.5   4.3   30.4       0  26410   .180    3.68     8
 13  2300   222.0    97   1.7  61.8   13.4       0    938  4.120   11.48   260
 14  2300   204.0    89   1.7  60.0   13.1       0   1140  4.500   10.66   155
 15  2300   182.0    80   1.7  59.0   12.8       0   1366  4.980    9.93   104
 16  2300   167.0    73   2.1  59.6   12.3       0   2299  5.960    8.68    85
 17  2300   111.0    49   2.9  42.5   16.0       0    929   .280   11.13   213
 18  2300    56.0    25  11.1  25.2   18.0       0    802   .100    8.93   127
 19  2300    40.0    18  13.4  22.6   18.0       0    449   .070    8.84   138
 20  2300    18.0     8  15.6  19.6   18.1       0    541   .070    8.75   135
 21  2300     4.0     2  13.0  15.4   18.6       0    808   .070    8.34    98
 22   600     0.0     0  17.9   4.0   16.5       0   1869  1.050    9.03    45
 23  2300     0.0     0  24.0   4.4   18.4       0  44311   .020     .13     4
-----------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
-----------------------------------------------------------------------------
  1    0.0   32.7     600     1.9  .070      0.0      I       R        R       R
  2    0.0    6.1     105     5.8  .060       .1    0.0    5.38     92.1     5.1
  3    0.0   23.8     101    14.0  .060       .2    0.0    5.79     24.4     3.4
  4    0.0   36.6      85    36.4  .050       .5    0.0    3.91      9.1     3.9
  5    0.0   46.7      96    56.7  .030       .4    0.0    3.52      7.2     4.3
  6    0.0   91.4     138   241.1  .060      1.6    0.0    3.48      5.3     9.2
  7    0.0   65.2     188   420.3 0.000      0.0    0.0    1.65      4.7    10.6
  8    0.0   84.4     563   335.6  .040      1.7    0.0    1.95     13.0     7.8
  9    0.0  147.7    9733    43.8 0.000      0.0    0.0    3.05    200.9      .9
 10    0.0  157.2   10259   121.8 0.000      0.0    0.0    2.99    195.2     2.3
 11    0.0   27.1     556     2.1  .070      0.0      I       R        R       R
 12    0.0  792.4     109      .8  .120      0.0      I       R        R       R
 13    0.0  167.6   14866   154.2  .025      2.4    0.0    1.72    152.9     1.6
 14    0.0  203.2   16197    91.7  .055      4.9    0.0    2.27    181.3     1.0
 15    0.0  242.9   17892    61.3  .035      2.8    0.0    3.05    224.5      .8
 16    0.0  418.0   21888    51.3  .060      4.4    0.0    5.72    299.3      .7
 17    0.0  155.6     948   118.2  .060      2.9    0.0    3.20     19.5     2.4
 18    0.0  100.6     253    53.1 0.000      0.0    0.0    4.10     10.3     2.2
 19    0.0   51.4     162    52.3  .065      1.1    0.0    2.94      9.2     3.0
 20    0.0   54.2     142    44.9 0.000      0.0    0.0    6.87     18.0     5.7
 21    0.0   66.5     116    26.6 0.000      0.0    0.0   37.96     66.4    15.2
 22    0.0   33.0     375     2.6  .080      0.0      I       R        R       R
 23    0.0 1930.5      18      .6  .060      0.0      I       R        R       R

CYCLE COMPOSITE    HC     12.716   GRAM/BHP HR
                   CO    149.368   GRAM/BHP HR
                   NO2     2.508   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .862     LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
     8-30-72 RUN-2 ENG.1-3 72 VER. 8 STD JETS 15 BTDC MODI.AIR O-Cat EGR TAID.
-------------------------------------------------------------------------------------
                DYNA.          MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEFD      LOAD     HP   VAC. LB/HR   RATIO     ALDE.     HC       CO       CO2     NO
-------------------------------------------------------------------------------------
  1    600       0.0      0   18.8    4.0    18.6         0   2364   1.940      8.84     29
  2   1200       5.0      1   19.9    7.7    23.3         0    888    .250      8.68     58
  3   1200      19.0      4   19.4    8.1    23.0         0    770    .180      9.03    107
  4   1200      43.0     10   17.2    9.6    22.0         0   1056    .130      9.50    420
  5   1200      60.0     14   16.0   10.6    21.9         0   1242    .130      9.50    540
  6   1200     120.0     27    9.4   16.0    21.1         0   1530    .100      9.93    900
  7   1200     180.0     41    2.0   24.2    17.9         0   1110    .490     11.36    820
  8   1200     197.0     45    1.9   25.1    17.1         0   1183    .700     11.84    830
  9   1200     221.0     50    2.0   25.2    17.7         0   1067    .470     11.60   2500
 10   1200     240.0     55     .5   34.7    13.3         0   2597   6.250      9.03    380
 11    600       0.0      0   19.0    3.9    17.9         0   2074   2.140      9.64     34
 12   1200       0.0      0   22.8    4.0    32.4         0  30647    .180      3.08      5
 13   2300     236.0    103    1.7   62.6    13.2         0   1146   4.690     11.13    370
 14   2300     217.0     95    1.7   61.1    12.9         0   1468   5.350     10.55    213
 15   2300     194.0     85    1.6   58.7    12.8         0   1999   5.900      9.50    102
 16   2300     177.0     78    2.5   49.1    14.5         0    311   1.910     12.09    260
 17   2300     118.0     52    3.7   36.1    17.8         0   1216    .350     11.01    400
 18   2300      59.0     26   14.0   22.4    21.3         0    360    .150      9.78    370
 19   2300      42.0     18   15.5   20.0    21.6         0    447    .130      9.64    270
 20   2300      19.0      8   17.1   17.7    22.4         0    684    .100      9.25    202
 21   2300       5.0      2   18.0   15.8    23.4         0   5507    .150      8.48    115
 22    600       0.0      0   18.9    4.0    18.6         0   2097   1.700      9.50     36
 23   2300       0.0      0   24.2    4.1    46.8         0  40642    .050       .33      3
-------------------------------------------------------------------------------------
            CALCULATED GRAM/HR        WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO      NO2  FAC.       HP  ALDE.       HC       CO     NO2
-------------------------------------------------------------------------------------
  1    0.0     38.9      645      1.6  .070      0.0      I        R        R       R
  2    0.0     34.4      196      7.5  .060       .1    0.0    30.09    171.2     6.6
  3    0.0     30.5      144     14.1  .060       .3    0.0     7.02     33.1     3.3
  4    0.0     47.3      117     62.4  .050       .5    0.0     4.81     12.0     6.3
  5    0.0     61.2      129     88.4  .030       .4    0.0     4.46      9.4     6.4
  6    0.0    109.0      144    213.0  .060      1.6    0.0     3.98      5.3     7.8
  7    0.0    101.8      908    249.8 0.000      0.0    0.0     2.48     22.1     6.1
  8    0.0    106.4     1272    247.8  .040      1.8    0.0     2.36     28.3     5.5
  9    0.0    100.2      891    779.2 0.000      0.0    0.0     1.98     17.6    15.4
 10    0.0    263.0    12788    127.8 0.000      0.0    0.0     4.80    233.2     2.3
 11    0.0     30.6      638      1.7  .070      0.0      I        R        R       R
 12    0.0    879.2      104       .5  .120      0.0      I        R        R       R
 13    0.0    204.3    16882    218.9  .025      2.6    0.0     1.98    163.3     2.1
 14    0.0    253.6    18665    121.8  .055      5.2    0.0     2.67    196.4     1.3
 15    0.0    341.2    20342     58.1  .035      3.0    0.0     4.02    239.4      .7
 16    0.0     49.3     6124    137.0  .060      4.7    0.0      .64     79.0     1.8
 17    0.0    173.4     1008    189.4  .060      3.1    0.0     3.35     19.5     3.7
 18    0.0     36.7      309    125.2 0.000      0.0    0.0     1.42     12.0     4.8
 19    0.0     41.3      243     82.9  .065      1.2    0.0     2.25     13.2     4.5
 20    0.0     58.3      172     57.3 0.000      0.0    0.0     7.01     2 .7     6.9
 21    0.0    429.9      237     29.8 0.000      0.0    0.0   196.34    108.0    13.6
 22    0.0     33.3      546      1.9  .080      0.0      I        R        R       R
 23    0.0   1700.7       42       .4  .060      0.0      I        R        R       R

CYCLF COMPOSITE    HC     11.513    GRAM/BHP HR
                   CO    116.460    GRAM/BHP HR
                   NO2     2.844    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .766      LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-31-72 RUN-3 ENG.1-3 72 VER. B STD TIM + JETS HOT TAID EGR O-CatNO AIR
---------------------------------------------------------------------------------
                  DYNA.          MAN.  FUEL     A/F               DRY CONCENTRATION
MODE SPEED        LOAD     HP   VAC.  LB/HR   RATIO    ALDE.     HC       CO       CO2      NO
---------------------------------------------------------------------------------
  1    600         0.0      0   17.8    3.8    14.9        0   3069    2.080    12.71      61
  2   1200         5.0      1   19.8    7.6    16.5        0   1083     .350    13.48     154
  3   1200        18.0      4   19.0    8.2    16.5        0    949     .280    13.77     155
  4   1200        41.0      9   17.2    9.7    17.1        0   1224     .150    13.18     500
  5   1200        58.0     13   16.0   10.6    17.4        0   1191     .150    13.18     670
  6   1200       115.0     26    9.7   15.9    18.0        0   1364     .130    12.59    1112
  7   1200       173.0     40    2.6   23.3    17.2        0    911     .150    13.33    1500
  8   1200       189.0     43    1.9   25.6    15.5        0   1569    1.050    13.77    1250
  9   1200       212.0     48    1.9   27.3    15.0        0   1726    1.450    14.05    1900
 10   1200       230.0     53     .5   34.3    12.4        0   3303    6.640    10.55     415
 11    600         0.0      0   17.9    3.9    14.3        0   3440    3.380    12.47      53
 12   1200         0.0      0   22.5    3.9    20.4        0  40302     .250     6.30      11
 13   2300       230.0    101    1.7   63.4    12.4        0   2729    6.440    11.01     310
 14   2300       212.0     93    1.7   61.9    12.2        0   2993    7.020    10.55     165
 15   2300       189.0     83    1.6   60.2    11.9        0   3251    7.620     9.78      93
 16   2300       173.0     76    2.1   61.4    11.3        0   4421    8.840     8.84      82
 17   2300       115.0     50    2.7   46.0    14.5        0   1161    2.320    12.59     145
 18   2300        58.0     25   10.7   25.6    17.1        0   1005     .150    12.47     136
 19   2300        41.0     18   12.9   21.4    17.2        0    112     .130    12.47     120
 20   2300        18.0      8   15.3   20.3    17.4        0    200     .100    11.92     163
 21   2300         5.0      2   17.9   15.8    18.0        0    999     .130    11.72     132
 22    600         0.0      0   17.8    3.9    15.2        0   2855    2.020    12.09      58
 23   2300         0.0      0   23.8    4.3    19.7        0  35058     .250     7.37      10
---------------------------------------------------------------------------------
          CALCULATED GRAM/HR           WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC        CO     NO2  FAC.        HP   ALDE.      HC       CO      NO2
---------------------------------------------------------------------------------
  1   0.0     35.0       480     2.3  .070       0.0       I        R        R        R
  2   0.0     26.8       175    12.6  .060        .1     0.0    23.44    153.1     11.1
  3   0.0     25.0       149    13.5  .060        .2     0.0     6.07     36.2      3.3
  4   0.0     40.0        99    54.3  .050        .5     0.0     4.27     10.6      5.8
  5   0.0     42.6       108    79.5  .030        .4     0.0     3.21      8.2      6.0
  6   0.0     76.5       147   207.2  .060       1.6     0.0     2.91      5.6      7.9
  7   0.0     70.9       236   387.8 0.000       0.0     0.0     1.79      6.0      9.8
  8   0.0    121.7      1644   321.8  .040       1.7     0.0     2.82     38.1      7.5
  9   0.0    136.4      2314   498.4 0.000       0.0     0.0     2.82     47.8     10.3
 10   0.0    293.3     11911   122.4 0.000       0.0     0.0     5.58    226.7      2.3
 11   0.0     37.6       746     1.9  .070       0.0       I        R        R        R
 12   0.0    673.9        84      .6  .120       0.0       I        R        R        R
 13   0.0    442.9     21109   167.0  .025       2.5     0.0     4.40    209.6      1.7
 14   0.0    470.4     22281    86.1  .055       5.1     0.0     5.07    240.0       .9
 15   0.0    500.8     23713    47.6  .035       2.9     0.0     6.05    286.5       .6
 16   0.0    679.5     27443    41.8  .060       4.5     0.0     8.97    362.2       .6
 17   0.0    161.2      6508    66.8  .060       3.0     0.0     3.20    129.2      1.3
 18   0.0     91.7       277    41.3 0.000       0.0     0.0     3.61     10.9      1.6
 19   0.0      8.6       202    30.7  .065       1.2     0.0      .48     11.3      1.7
 20   0.0     15.3       154    41.3 0.000       0.0     0.0     1.94     19.6      5.2
 21   0.0     54.9       157    26.4 0.000       0.0     0.0    27.35     71.9     12.0
 22   0.0     35.1       501     2.4  .080       0.0       I        R        R        R
 23   0.0    614.6        69      .6  .060       0.0       I        R        R        R

CYCLE COMPOSITE    HC     10.401    GRAM/BHP HR
                   CO    205.424    GRAM/BHP HR
                   NO2     2.176    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .852      LB/BHP HR
```

ENGINE 1-3

EFFECT OF VARIOUS COMBINATIONS ON EMISSIONS

TABULAR DATA

AFTER CATALYST

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-31-72 RUN-1 ENG.1-3 72 VER. 15 BTDC AIR MODI.0.063 JETS O-Cat  A
-------------------------------------------------------------------------------------
                DYNA.         MAN.  FUEL     A/F                DRY CONCENTRATION
MODE SPEED      LOAD    HP    VAC.  LB/HR    RATIO    ALDE.    HC       CO      CO2      NO
-------------------------------------------------------------------------------------
  1    600       0.0     0    19.7    3.9    19.1       0      411     .050    11.92     34
  2   1200       5.0     1    20.9    7.0    23.2       0       97     .100     9.64     58
  3   1200      18.0     4    19.9    8.1    22.3       0      162     .050    10.25    109
  4   1200      41.0     9    18.7    9.2    21.8       0      261     .100    10.43    455
  5   1200      58.0    13    17.6   10.4    20.6       0      334     .100    11.13    665
  6   1200     115.0    26    13.1   15.8    18.1       0      548     .130    12.71   1563
  7   1200     173.0    40     8.4   22.6    16.5       0      707     .350    13.77   1138
  8   1200     189.0    43     7.3   23.8    16.2       0      690     .440    13.77   1013
  9   1200     212.0    48     4.7   27.2    15.6       0      592     .740    14.31    650
 10   1200     230.0    53      .5   41.4    11.5       0     4962    9.500     8.60    113
 11    600       0.0     0    19.6    4.0    17.9       0      412     .070    12.71     34
 12   1200       0.0     0    23.0    4.0    31.5       0     3267     .100     6.64      6
 13   2300     248.0   109     1.8   76.7    12.2       0     2022    8.010     9.64    160
 14   2300     228.0   100     3.3   60.5    14.3       0      433    2.730    13.06   1050
 15   2300     203.0    89     5.2   55.2    14.4       0      332    2.250    13.48    805
 16   2300     186.0    81     6.8   50.8    14.5       0      283    1.980    13.48    820
 17   2300     124.0    54    11.3   38.7    15.1       0       82     .740    14.05    610
 18   2300      62.0    27    16.2   26.2    16.9       0       38     .100    12.94    555
 19   2300      45.0    20    17.7   21.8    18.1       0       40     .050    12.09    490
 20   2300      20.0     9    19.4   17.0    20.4       0       45     .050    10.78    305
 21   2300       5.0     2    20.5   13.9    23.6       0      217     .050     9.14    158
 22    600       0.0     0    19.8    3.9    20.3       0      314     .050    11.01     47
 23   2300       0.0     0    24.1    4.2    49.4       0     2618     .250     3.74      3
-------------------------------------------------------------------------------------
         CALCULATED GRAM/HR             WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2    FAC.       HP   ALDE.      HC       CO     NO2
-------------------------------------------------------------------------------------
  1   0.0      6.1      15     1.7    .070      0.0      I        R        R       R
  2   0.0      3.2      66     6.3    .060       .1    0.0     2.77     57.6     5.5
  3   0.0      5.8      36    12.9    .060       .2    0.0     1.40      8.7     3.1
  4   0.0     10.3      80    59.7    .050       .5    0.0     1.10      8.5     6.4
  5   0.0     14.0      85    92.5    .030       .4    0.0     1.06      6.4     7.0
  6   0.0     30.5     146   288.4    .060      1.6    0.0     1.16      5.6    11.0
  7   0.0     51.0     511   272.9   0.000      0.0    0.0     1.29     12.9     6.9
  8   0.0     52.2     672   254.3    .040      1.7    0.0     1.21     15.6     5.9
  9   0.0     48.4    1221   176.2   0.000      0.0    0.0     1.00     25.2     3.6
 10   0.0    501.0   19379    37.9   0.000      0.0    0.0     9.53    368.8      .7
 11   0.0      5.8      20     1.6    .070      0.0      I        R        R       R
 12   0.0     83.9      52      .5    .120      0.0      I        R        R       R
 13   0.0    394.0   31533   103.5    .025      2.7    0.0     3.63    290.3     1.0
 14   0.0     75.1    9558   604.2    .055      5.5    0.0      .75     95.7     6.1
 15   0.0     52.8    7219   424.5    .035      3.1    0.0      .59     81.2     4.8
 16   0.0     42.2    5950   405.0    .060      4.9    0.0      .52     73.1     5.0
 17   0.0      9.7    1773   240.2    .060      3.3    0.0      .18     32.7     4.4
 18   0.0      3.5     184   167.9   0.000      0.0    0.0      .13      6.8     6.2
 19   0.0      3.3      82   132.5    .065      1.3    0.0      .17      4.2     6.7
 20   0.0      3.2      72    72.1   0.000      0.0    0.0      .37      8.2     8.2
 21   0.0     14.9      69    35.9   0.000      0.0    0.0     6.78     31.6    16.4
 22   0.0      5.0      16     2.5    .080      0.0      I        R        R       R
 23   0.0    117.3     226      .4    .060      0.0      I        R        R       R

CYCLE COMPOSITE    HC       1.699    GRAM/BHP HR
                   CO      83.523    GRAM/BHP HR
                   NO2      5.268    GRAM/BHP HR
       418    4    ALDE     0.000    GRAM/BHP HR
                   BSFC      .759      LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-31-72 RUN-2 ENG.1-3 72 VER. A 6 BTDC 0.063 JETS MODI.AIR  O-Cat
--------------------------------------------------------------------------------------
            DYNA.          MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED   LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC       CO       CO2     NO
--------------------------------------------------------------------------------------
  1    600     0.0     0   18.5    4.0    18.2        0    328     .020    11.92     42
  2   1200     4.0     1   20.2    7.2    22.9        0     80     .020     9.25     60
  3   1200    17.0     4   19.0    8.4    22.1        0    146     .020     9.64    186
  4   1200    38.0     9   18.0    9.5    21.9        0    183     .020     9.64    350
  5   1200    53.0    12   17.7   10.2    20.4        0    202     .020    10.43    360
  6   1200   105.0    24   13.8   15.2    17.8        0    383     .050    11.92   1062
  7   1200   158.0    36    9.5   21.5    16.2        0    471     .180    12.94    930
  8   1200   172.0    39    8.0   23.0    15.9        0    428     .350    13.06    800
  9   1200   193.0    44    4.9   27.4    15.1        0    252     .810    13.18    450
 10   1200   210.0    48     .5   40.8    11.4        0   3764    8.630     8.48     99
 11    600     0.0     0   18.8    4.1    18.6        0    282     .070    11.24     55
 12   1200     0.0     0   22.2    4.1    29.9        0   3160     .100     6.64     12
 13   2300   236.0   103    1.8   76.0    11.9        0   1582    8.010     9.64    111
 14   2300   217.0    95    2.0   80.0    11.2        0   1933    9.910     8.60     72
 15   2300   194.0    85    4.3   57.2    14.2        0    303    2.480    12.82    630
 16   2300   177.0    78    6.5   51.9    14.3        0    282    2.180    12.94    560
 17   2300   118.0    52   11.8   37.6    15.2        0     75     .420    13.63    440
 18   2300    59.0    26   16.1   26.2    17.0        0     51     .020    12.71    370
 19   2300    42.0    18   17.5   22.5    17.9        0     42     .020    11.92    340
 20   2300    19.0     8   19.1   18.2    15.7        0     38     .020    10.55    250
 21   2300     5.0     2   20.2   15.4    21.6        0     37     .020     9.25    145
 22    600     0.0     0   18.5    4.0    19.2        0    311     .020    10.66     52
 23   2300     0.0     0   23.9    4.3    39.5        0    908     .070     3.95      3
--------------------------------------------------------------------------------------
        CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2  FAC.      HP  ALDE.      HC       CO      NO2
--------------------------------------------------------------------------------------
  1    0.0    5.0       6     2.1  .070     0.0      I       R        R        R
  2    0.0    2.8      14     7.0  .060      .1    0.0    3.09     15.6      7.7
  3    0.0    5.7      16    24.3  .060      .2    0.0    1.48      4.1      6.3
  4    0.0    8.1      18    51.7  .050      .4    0.0     .94      2.1      6.0
  5    0.0    8.9      18    52.8  .030      .4    0.0     .74      1.5      4.4
  6    0.0   22.0      58   202.4  .060     1.4    0.0     .92      2.4      8.4
  7    0.0   34.9     269   228.7 0.000     0.0    0.0     .97      7.5      6.3
  8    0.0   33.2     548   206.0  .040     1.6    0.0     .85     14.0      5.2
  9    0.0   22.3    1451   132.5 0.000     0.0    0.0     .51     32.9      3.0
 10    0.0  398.4   18450    34.8 0.000     0.0    0.0    8.30    384.5       .7
 11    0.0    4.6      23     3.0  .070     0.0      I       R        R        R
 12    0.0   83.3      53     1.1  .120     0.0      I       R        R        R
 13    0.0  306.3   31322    71.3  .025     2.6    0.0    2.96    303.1       .7
 14    0.0  374.9   38839    46.4  .055     5.2    0.0    3.95    408.7       .5
 15    0.0   51.2    8479   354.0  .035     3.0    0.0     .60     99.8      4.2
 16    0.0   43.8    6844   288.9  .060     4.7    0.0     .56     88.3      3.7
 17    0.0    9.0    1029   177.2  .060     3.1    0.0     .18     19.9      3.4
 18    0.0    4.8      38   114.6 0.000     0.0    0.0     .19      1.5      4.4
 19    0.0    3.6      35    96.5  .065     1.2    0.0     .20      1.9      5.2
 20    0.0    3.0      32    64.8 0.000     0.0    0.0     .36      3.8      7.8
 21    0.0    2.8      30    36.3 0.000     0.0    0.0    1.27     13.9     16.6
 22    0.0    5.3       7     2.9  .080     0.0      I       R        R        R
 23    0.0   43.1      67      .5  .060     0.0      I       R        R        R

CYCLE COMPOSITE    HC       2.140    GRAM/BHP HR
                   CO     156.636    GRAM/BHP HR
                   NO2      3.280    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .853      LB/BHP HR
```

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-28-72 RUN-2 ENG.1-3 72 VERS.STD.TIME.+ JETS A W/AIR TAILORED EGR O-Cat
------------------------------------------------------------------------------
            DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED  LOAD    HP  VAC. LB/HR  RATIO    ALDE.    HC       CO      CO2     NO
------------------------------------------------------------------------------
  1   600     0.0    0  18.1   4.1   19.7        0    386    .050    11.01     53
  2  1200     4.0    1  19.6   7.6   23.3        0    128    .050     9.14     65
  3  1200    18.0    4  19.1   8.1   23.0        0    141    .050     9.37    105
  4  1200    40.0    9  17.1   9.5   22.5        0    201    .050     9.50    178
  5  1200    56.0   13  15.0  11.3   22.4        0    212    .050     9.64    205
  6  1200   156.0   36   1.9  24.2   17.8        0    217    .070    12.22    555
  7  1200   167.0   38   1.8  25.4   16.9        0    213    .100    12.71    580
  8  1200   182.0   42   1.7  26.9   15.8        0    208    .250    13.33    370
  9  1200   204.0   47    .5  33.3   13.4        0   1290   4.160    11.72    230
 10  1200   222.0   51    .5  34.4   13.5        0   1178   3.840    11.72    450
 11   600     0.0    0  18.5   4.2   19.0        0    348    .050    11.24     50
 12  1200     0.0    0  22.3   4.3   33.0        0    392    .050     6.38      8
 13  2300   220.0   96   1.7  62.1   13.7        0    460   3.150    12.22    285
 14  2300   202.0   88   1.7  60.5   13.5        0    553   3.470    11.60    159
 15  2300   180.0   79   2.4  56.8   13.8        0    396   2.600    11.72    178
 16  2300   165.0   72   2.6  52.0   14.9        0     68    .420    12.59    233
 17  2300   110.0   48   3.0  43.4   18.0        0    225    .100    10.55    285
 18  2300    55.0   24  13.3  24.2   19.5        0    102    .020     9.03    260
 19  2300    40.0   18  15.0  21.4   19.4        0     79    .020     8.75    225
 20  2300    18.0    8  16.6  18.7   19.6        0     95    .020     8.48    154
 21  2300     4.0    2  17.8  16.2   19.6        0    593    .050     8.34     89
 22   600     0.0    0  18.0   4.0   17.3        0    321    .050    10.43     52
 23  2300     0.0    0  24.0   4.4   33.2        0   2174    .150     3.68      5
------------------------------------------------------------------------------
         CALCULATED GRAM/HR         WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC      CO     NO2  FAC.     HP  ALDE.     HC      CO     NO2
------------------------------------------------------------------------------
  1   0.0    6.5      17     2.9  .070    0.0      I      R       R       R
  2   0.0    4.8      38     8.1  .060     .1    0.0   5.25    41.4     8.8
  3   0.0    5.5      39    13.6  .060     .2    0.0   1.34     9.6     3.3
  4   0.0    9.1      45    26.6  .050     .5    0.0    .99     5.0     2.9
  5   0.0   11.2      53    35.9  .030     .4    0.0    .88     4.2     2.8
  6   0.0   19.4     126   164.3  .060    2.1    0.0    .54     3.5     4.6
  7   0.0   19.1     181   172.9 0.000    0.0    0.0    .50     4.8     4.5
  8   0.0   18.7     453   110.2  .040    1.7    0.0    .45    10.9     2.7
  9   0.0  121.7    7929    72.0 0.000    0.0    0.0   2.61   170.1     1.5
 10   0.0  117.3    7720   148.7 0.000    0.0    0.0   2.31   152.2     2.9
 11   0.0    5.9      17     2.8  .070    0.0      I      R       R       R
 12   0.0   11.8      30      .8  .120    0.0      I      R       R       R
 13   0.0   84.1   11627   172.9  .025    2.4    0.0    .87   120.7     1.8
 14   0.0  100.3   12718    95.8  .055    4.9    0.0   1.13   143.8     1.1
 15   0.0   71.1    9423   106.0  .035    2.8    0.0    .90   119.5     1.3
 16   0.0   12.4    1537   140.2  .060    4.3    0.0    .17    21.3     1.9
 17   0.0   41.5     373   174.5  .060    2.9    0.0    .86     7.7     3.6
 18   0.0   12.3      49   104.6 0.000    0.0    0.0    .51     2.0     4.3
 19   0.0    8.7      45    82.6  .065    1.1    0.0    .50     2.6     4.7
 20   0.0    9.5      40    51.0 0.000    0.0    0.0   1.20     5.1     6.5
 21   0.0   51.5      88    25.7 0.000    0.0    0.0  29.43    50.1    14.7
 22   0.0    5.5      17     3.0  .080    0.0      I      R       R       R
 23   0.0  107.2     149      .8  .060    0.0      I      R       R       R

CYCLE COMPOSITE    HC     1.130    GRAM/BHP HR
                   CO    63.750    GRAM/BHP HR
                   NO2    2.412    GRAM/BHP HR
                   ALDE   0.000    GRAM/BHP HR
                   BSFC    .855      LB/BHP HR
```

```
                        PROJECT 11-2877-01  CONTROL TECHNOLOGY
8-30-72 RUN-1 ENG.1-3 72 VER. TDC STD JETS AIR MODI. EGR TAILORED A
-----------------------------------------------------------------------------------------
                DYNA.         MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED      LOAD    HP    VAC. LB/HR   RATIO    ALDE.      HC        CO       CO2      NO
-----------------------------------------------------------------------------------------
   1   600       0.0     0   17.4    4.4    19.8        0     242      .050     10.89      61
   2  1200       4.0     1   19.5    7.9    22.8        0      87      .050      9.37      63
   3  1200      16.0     4   19.0    8.4    22.5        0     109      .050      9.50      92
   4  1200      36.0     8   17.0    9.6    22.1        0     173      .050      9.78     213
   5  1200      51.0    12   15.7   11.3    21.7        0     184      .050      9.93     218
   6  1200     101.0    23    8.6   16.4    20.7        0     263      .050     10.43     330
   7  1200     152.0    35    2.0   24.7    17.6        0     104      .050     10.25     475
   8  1200     166.0    38     .6   33.4    13.1        0    1197     4.690     11.60     108
   9  1200     186.0    42    2.0   26.3    16.5        0     101      .070     12.94    1138
  10  1200     202.0    46     .5   34.7    13.3        0     959     4.210     11.84     290
  11   600       0.0     0   17.4    4.3    19.3        0     268      .050     11.01      62
  12  1200       0.0     0   21.7    4.6    27.7        0    4748      .050      7.18      18
  13  2300     205.0    90    1.8   63.6    13.5        0     480     3.610     11.92     213
  14  2300     189.0    83    1.7   62.7    13.5        0     502     3.560     11.72     176
  15  2300     168.0    74    1.7   60.0    13.3        0     547     3.840     11.24      90
  16  2300     154.0    67    1.7   60.0    13.3        0     654     4.020     10.89      73
  17  2300     103.0    45    2.9   44.9    17.9        0      72      .050     11.13     184
  18  2300      51.0    22    9.5   28.6    21.2        0     397      .020      9.37     128
  19  2300      37.0    16   11.8   25.3    21.9        0     223      .020      9.25     113
  20  2300      16.0     7   14.8   21.3    22.8        0     184      .020      8.84      96
  21  2300       4.0     2   17.5   16.9    23.8        0     243      .020      8.54     101
  22   600       0.0     0   17.2    4.1    20.9        0     213      .020      9.78      68
  23  2300       0.0     0   23.6    4.8    45.4        0     365      .130      4.36       3
-----------------------------------------------------------------------------------------
           CALCULATED GRAM/HR          WT.       WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.       HC       CO     NO2  FAC.        HP  ALDE.       HC       CO     NO2
-----------------------------------------------------------------------------------------
   1   0.0      4.4       18     3.7  .070       0.0      I        R        R       R
   2   0.0      3.3       38     7.9  .060        .1    0.0     3.62     42.0     8.7
   3   0.0      4.3       40    12.2  .060        .2    0.0     1.19     11.0     3.3
   4   0.0      7.7       45    31.3  .050        .4    0.0      .93      5.4     3.8
   5   0.0      9.4       52    37.1  .030        .3    0.0      .81      4.4     3.2
   6   0.0     18.6       72    77.6  .060       1.4    0.0      .81      3.1     3.4
   7   0.0     11.3      110   171.4 0.000       0.0    0.0      .33      3.2     4.9
   8   0.0    110.5     8747    33.1  .040       1.5    0.0     2.91    230.6      .9
   9   0.0      9.2      130   346.2 0.000       0.0    0.0      .22      3.0     8.1
  10   0.0     93.5     8290    93.9 0.000       0.0    0.0     2.03    179.6     2.0
  11   0.0      4.7       18     3.6  .070       0.0      I        R        R       R
  12   0.0    128.6       27     1.6  .120       0.0      I        R        R       R
  13   0.0     89.0    13504   131.0  .025       2.2    0.0      .99    150.4     1.5
  14   0.0     93.2    13341   108.4  .055       4.6    0.0     1.13    161.2     1.3
  15   0.0     98.4    13949    53.7  .035       2.6    0.0     1.34    189.6      .7
  16   0.0    118.9    14758    44.0  .060       4.0    0.0     1.76    218.8      .7
  17   0.0     13.1      184   111.2  .060       2.7    0.0      .29      4.1     2.5
  18   0.0     54.6       56    58.5 0.000       0.0    0.0     2.44      2.5     2.6
  19   0.0     27.5       50    46.3  .065       1.1    0.0     1.70      3.1     2.9
  20   0.0     20.0       44    34.7 0.000       0.0    0.0     2.86      6.3     4.9
  21   0.0     21.7       36    29.9 0.000       0.0    0.0    12.38     20.6    17.1
  22   0.0      4.0        8     4.3  .080       0.0      I        R        R       R
  23   0.0     17.5      126      .5  .060       0.0      I        R        R       R

CYCLE COMPOSITE    HC       2.112   GRAM/BHP HR
                   CO     134.315   GRAM/BHP HR
                   NO2      1.628   GRAM/BHP HR
                   ALDE     0.000   GRAM/BHP HR
                   BSFC      .993     LB/BHP HR
```

```
                     PROJECT 11-2877-01  CONTROL TECHNOLOGY
8-29-72 RUN-1 ENG.1-3 72 VER. STD TIM.+JETS MODI.AIR+EGR TAILORED A O-Cat
-------------------------------------------------------------------------------
                                                        DRY CONCENTRATION
             DYNA.       MAN. FUEL    A/F
MODE SPEED   LOAD   HP   VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2     NO
-------------------------------------------------------------------------------
  1   600     0.0    0   17.8   4.0   18.5      0     366    .050   11.84     46
  2  1200     5.0    1   19.6   7.4   22.8      0     177    .050    9.37     50
  3  1200    18.0    4   18.9   8.3   22.4      0     153    .050    9.64    100
  4  1200    41.0    9   17.5   9.4   22.3      0     205    .050    9.64    215
  5  1200    58.0   13   16.1  10.6   22.2      0     219    .020    9.64    315
  6  1200   115.0   26    9.9  15.8   21.1      0     328    .020   10.25    930
  7  1200   173.0   40    2.6  23.6   18.9      0    2268    .020   11.48   1225
  8  1200   189.0   43    2.0  25.5   17.1      0     210    .050   12.59   1063
  9  1200   212.0   48    1.0  29.3   13.0      0    1426   4.880   11.36    178
 10  1200   230.0   53     .5  34.8   13.4      0    1122   3.790   11.84    450
 11   600     0.0    0   18.4   4.1   19.0      0     313    .050   11.24     49
 12  1200     0.0    0   22.5   4.3   32.7      0     482    .020    6.30      8
 13  2300   222.0   97    1.7  61.8   13.6      0     507   3.190   11.92    280
 14  2300   204.0   89    1.7  60.0   13.5      0     597   3.330   11.36    168
 15  2300   182.0   80    1.7  59.0   13.3      0     771   3.790   10.66    113
 16  2300   167.0   73    2.1  59.6   12.8      0    1256   4.690    9.50     93
 17  2300   111.0   49    2.9  42.5   16.0      0     131    .050   10.66    219
 18  2300    56.0   25   11.1  25.2   17.8      0     228    .020    9.37    150
 19  2300    40.0   18   13.4  22.6   18.0      0     133    .020    8.93    141
 20  2300    18.0    8   15.6  19.6   18.3      0     189    .020    8.75    128
 21  2300     4.0    2   18.0  15.4   18.8      0     829    .020    8.24     83
 22   600     0.0    0   17.9   4.0   17.3      0     290    .020   10.09     51
 23  2300     0.0    0   24.0   4.4   29.8      0    2146    .150    3.56      3
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC      CO    NO2    FAC.     HP   ALDE.     HC      CO     NO2
-------------------------------------------------------------------------------
  1   0.0     5.6     15    2.3    .070    0.0      I       R       R       R
  2   0.0     6.3     36    5.9    .060     .1    0.0    5.52    31.4     5.2
  3   0.0     5.9     39   12.9    .060     .2    0.0    1.44     9.5     3.1
  4   0.0     9.0     44   31.3    .050     .5    0.0     .96     4.7     3.3
  5   0.0    10.9     20   51.9    .030     .4    0.0     .82     1.5     3.9
  6   0.0    22.4     28  214.8    .060    1.6    0.0     .87     1.1     8.2
  7   0.0   207.0     37  371.3   0.000    0.0    0.0    5.24      .9     9.4
  8   0.0    19.2     92  322.4    .040    1.7    0.0     .44     2.1     7.5
  9   0.0   115.7   7997   47.9   0.000    0.0    0.0    2.39   165.1     1.0
 10   0.0   112.5   7677  149.8   0.000    0.0    0.0    2.14   146.1     2.9
 11   0.0     5.1     17    2.7    .070    0.0      I       R       R       R
 12   0.0    14.8     12     .8    .120    0.0      I       R       R       R
 13   0.0    93.8  11915  171.9    .025    2.4    0.0     .96   122.6     1.8
 14   0.0   110.2  12412  102.9    .055    4.9    0.0    1.23   138.9     1.2
 15   0.0   142.0  14104   69.1    .035    2.8    0.0    1.78   177.0      .9
 16   0.0   237.1  17891   58.3    .060    4.4    0.0    3.24   244.6      .8
 17   0.0    23.5    182  130.7    .060    2.9    0.0     .48     3.7     2.7
 18   0.0    27.7     49   60.5   0.000    0.0    0.0    1.13     2.0     2.5
 19   0.0    15.2     46   53.5    .065    1.1    0.0     .87     2.6     3.1
 20   0.0    19.1     41   43.0   0.000    0.0    0.0    2.43     5.2     5.5
 21   0.0    69.4     34   23.1   0.000    0.0    0.0   39.62    19.3    13.2
 22   0.0     5.2      7    3.0    .080    0.0      I       R       R       R
 23   0.0   109.1    154     .5    .060    0.0      I       R       R       R

CYCLE COMPOSITE    HC       1.871    GRAM/BHP HR
                   CO     112.208    GRAM/BHP HR
                   NO2      2.513    GRAM/BHP HR
                   ALDE     0.000    GRAM/BHP HR
                   BSFC      .862      LB/BHP HR
```

.422

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
   8-30-72 RUN-2 ENG.1-3 72 VER. A STD JETS 15 BTDC MODI.AIR O-Cat EGR TAID.
------------------------------------------------------------------------------
              DYNA.         MAN. FUEL     A/F               DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC      CO      CO2     NO
------------------------------------------------------------------------------
  1   600      0.0     0   18.8    4.0   19.3       0     463    .050   11.01     39
  2  1200      5.0     1   19.9    7.7   23.7       0     206    .050    8.93     61
  3  1200     19.0     4   19.4    8.1   23.2       0     204    .050    9.14    111
  4  1200     43.0    10   17.2    9.6   22.6       0     261    .050    9.37    395
  5  1200     60.0    14   16.0   10.6   22.4       0     294    .050    9.37    510
  6  1200    120.0    27    9.4   16.0   21.2       0     377    .050   10.09    795
  7  1200    180.0    41    2.0   24.2   17.9       0     414    .100   11.92    860
  8  1200    197.0    45    1.9   25.1   17.1       0     427    .100   12.22     79
  9  1200    221.0    50    2.0   25.2   17.7       0     437    .100   11.92   2400
 10  1200    240.0    55     .5   34.7   13.2       0    2013   4.540   11.01    560
 11   600      0.0     0   19.0    3.9   18.7       0     382    .050   11.48     42
 12  1200      0.0     0   22.8    4.0   32.0       0    3650    .050    6.21      6
 13  2300    236.0   103    1.7   62.6   13.6       0     610   3.380   11.84    420
 14  2300    217.0    95    1.7   61.1   13.3       0     915   4.070   11.48    275
 15  2300    194.0    85    1.6   58.7   13.0       0    1165   4.450   10.89    130
 16  2300    177.0    78    2.5   49.1   15.2       0      36    .350   12.82    270
 17  2300    118.0    52    3.7   36.1   18.7       0     339    .100   10.89    340
 18  2300     59.0    26   14.0   22.4   21.3       0     116    .050    9.93    370
 19  2300     42.0    18   15.5   20.0   22.2       0     177    .050    9.50    250
 20  2300     19.0     8   17.1   17.7   23.2       0     287    .050    8.93    180
 21  2300      5.0     2   18.0   15.8   24.1       0    2429    .050    8.54    113
 22   600      0.0     0   18.9    4.0   19.2       0     356    .050   11.13     42
 23  2300      0.0     0   24.2    4.1   51.7       0    4439    .100    3.40      3
------------------------------------------------------------------------------
        CALCULATED GRAM/HR          WT.       WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.       HP  ALDE.      HC       CO     NO2
------------------------------------------------------------------------------
  1   0.0     7.6       17     2.1  .070      0.0      I       R        R       R
  2   0.0     8.0       39     7.9  .060       .1    0.0    6.99     34.3     6.9
  3   0.0     8.1       40    14.7  .060       .3    0.0    1.87      9.3     3.4
  4   0.0    12.0       47    60.5  .050       .5    0.0    1.22      4.7     6.2
  5   0.0    14.9       51    86.2  .030       .4    0.0    1.09      3.7     6.3
  6   0.0    26.9       72   188.2  .060      1.6    0.0     .98      2.6     6.9
  7   0.0    37.7      184   259.9 0.000      0.0    0.0     .92      4.5     6.3
  8   0.0    39.3      186    24.2  .040      1.8    0.0     .87      4.1      .5
  9   0.0    41.4      191   755.0 0.000      0.0    0.0     .82      3.8    15.0
 10   0.0   201.2     9164   185.8 0.000      0.0    0.0    3.67    167.1     3.4
 11   0.0     5.8       15     2.1  .070      0.0      I       R        R       R
 12   0.0   100.0       28      .5  .120      0.0      I       R        R       R
 13   0.0   113.4    12687   259.1  .025      2.6    0.0    1.10    122.8     2.5
 14   0.0   162.1    14567   161.8  .055      5.2    0.0    1.71    153.3     1.7
 15   0.0   200.6    15485    74.4  .035      3.0    0.0    2.36    182.3      .9
 16   0.0     6.1     1195   151.5  .060      4.7    0.0     .08     15.4     2.0
 17   0.0    50.4      300   167.7  .060      3.1    0.0     .98      5.8     3.2
 18   0.0    11.8      103   124.9 0.000      0.0    0.0     .46      4.0     4.8
 19   0.0    16.8       96    78.7  .065      1.2    0.0     .91      5.2     4.3
 20   0.0    25.6       90    53.3 0.000      0.0    0.0    3.07     10.8     6.4
 21   0.0   197.1       82    30.4 0.000      0.0    0.0   90.00     37.4    13.9
 22   0.0     5.8       16     2.3  .080      0.0      I       R        R       R
 23   0.0   209.3       95      .5  .060      0.0      I       R        R       R

CYCLE COMPOSITE    HC      2.229   GRAM/BHP HR
                   CO     73.307   GRAM/BHP HR
                   NO2     2.542   GRAM/BHP HR
                   ALDE    0.000   GRAM/BHP HR
                   BSFC     .766     LB/BHP HR
```

```
                      PROJECT 11-2877-01  CONTROL TECHNOLOGY
  8-31-72 RUN-3 ENG.1-3 72 VER. A STD TIM + JETS HOT TAID EGR O-Cat NO AIR
-------------------------------------------------------------------------------
             DYNA.        MAN. FUEL    A/F             DRY CONCENTRATION
MODE SPEED    LOAD   HP   VAC. LB/HR  RATIO   ALDE.     HC      CO      CO2     NO
-------------------------------------------------------------------------------
  1    600     0.0    0   17.8    3.8   15.8      0   2547    .810   13.48     57
  2   1200     5.0    1   19.8    7.6   16.9      0    146    .050   13.48     89
  3   1200    18.0    4   19.0    8.2   16.8      0    165    .050   13.77    148
  4   1200    41.0    9   17.2    9.7   17.5      0    213    .050   13.18    465
  5   1200    58.0   13   16.0   10.6   17.8      0    213    .050   12.94    640
  6   1200   115.0   26    9.7   15.9   18.3      0    280    .050   12.71    940
  7   1200   173.0   40    2.6   23.3   17.3      0    245    .050   13.18   1363
  8   1200   189.0   43    1.9   25.6   15.6      0    563    .390   14.53   1063
  9   1200   212.0   48    1.9   27.3   15.2      0    850    .770   14.42   1450
 10   1200   230.0   53     .5   34.3   12.7      0   3180   5.900   11.01    505
 11    600     0.0    0   17.9    3.9   15.4      0   3036   1.660   12.94     48
 12   1200     0.0    0   22.5    3.9   21.9      0   5645    .020    9.50     12
 13   2300   230.0  101    1.7   63.4   12.5      0   4982   5.670   11.48    365
 14   2300   212.0   93    1.7   61.9   12.5      0   2665   6.130   11.01    199
 15   2300   189.0   83    1.6   60.2   12.3      0   2807   6.500   10.55    108
 16   2300   173.0   76    2.1   61.4   11.8      0   3421   7.620    9.64     92
 17   2300   115.0   50    2.7   46.0   15.1      0    317   1.010   13.18    123
 18   2300    58.0   25   10.7   25.6   17.0      0    235    .050   12.59    133
 19   2300    41.0   18   12.9   21.4   17.2      0    112    .050   12.71    121
 20   2300    18.0    8   15.3   20.3   17.6      0     71    .050   11.92    155
 21   2300     5.0    2   17.9   15.8   18.3      0    521    .050   11.72    119
 22    600     0.0    0   17.8    3.9   16.0      0   2404    .850   12.59     57
 23   2300     0.0    0   23.8    4.3   22.2      0  10067    .070    8.68     10
-------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO     NO2   FAC.      HP   ALDE.     HC      CO     NO2
-------------------------------------------------------------------------------
  1   0.0    30.2     194     2.2   .070     0.0      I       R       R       R
  2   0.0     3.7      26     7.5   .060      .1    0.0    3.26    22.5     6.6
  3   0.0     4.4      27    13.2   .060      .2    0.0    1.08     6.6     3.2
  4   0.0     7.1      34    51.3   .050      .5    0.0     .76     3.6     5.5
  5   0.0     7.9      37    78.5   .030      .4    0.0     .59     2.8     5.9
  6   0.0    15.8      57   176.0   .060     1.6    0.0     .60     2.2     6.7
  7   0.0    19.5      81   360.8  0.000     0.0    0.0     .49     2.0     9.1
  8   0.0    43.7     611   273.6   .040     1.7    0.0    1.01    14.1     6.3
  9   0.0    68.9    1261   390.3  0.000     0.0    0.0    1.42    26.0     8.1
 10   0.0   287.2   10763   151.4  0.000     0.0    0.0    5.47   204.8     2.9
 11   0.0    36.0     398     1.9   .070     0.0      I       R       R       R
 12   0.0    99.0       7      .7   .120     0.0      I       R       R       R
 13   0.0   811.9   18664   197.5   .025     2.5    0.0    8.06   185.3     2.0
 14   0.0   429.8   19974   106.6   .055     5.1    0.0    4.63   215.1     1.1
 15   0.0   442.3   20688    56.5   .035     2.9    0.0    5.34   249.9      .7
 16   0.0   541.3   24355    48.3   .060     4.5    0.0    7.14   321.5      .6
 17   0.0    46.5    2993    59.9   .060     3.0    0.0     .92    59.4     1.2
 18   0.0    21.5      93    40.5  0.000     0.0    0.0     .85     3.6     1.6
 19   0.0     8.5      77    30.5   .065     1.2    0.0     .47     4.3     1.7
 20   0.0     5.5      78    39.6  0.000     0.0    0.0     .69     9.9     5.0
 21   0.0    31.6      61    24.0  0.000     0.0    0.0   14.43    28.0    10.9
 22   0.0    31.1     222     2.4   .080     0.0      I       R       R       R
 23   0.0   201.2      28      .7   .060     0.0      I       R       R       R

CYCLE COMPOSITE    HC      5.480    GRAM/BHP HR
                   CO    169.778    GRAM/BHP HR
                   NO2     2.086    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .852      LB/BHP HR
```

ENGINE 1-3

EFFECT OF VARIOUS COMBINATIONS ON EMISSIONS

GRAPHED RESULTS

OF AFTER CATALYST WITH HOT EGR
PER SCHEDULE A, WITH AIR INJECTION
AND STANDARD CARBURETOR

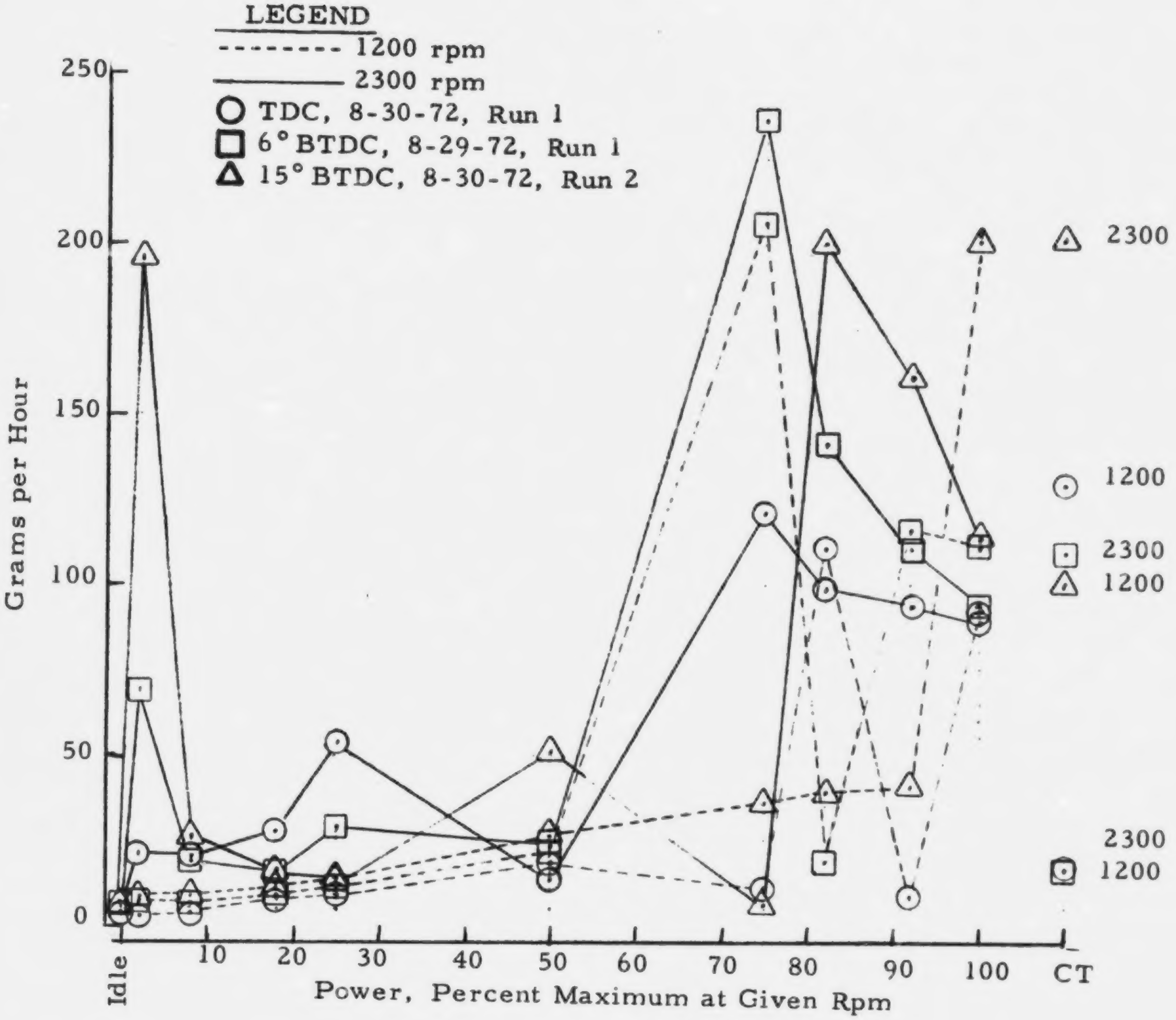


FIGURE V-1. EFFECT OF POWER ON HC EMISSION RATE AFTER CATALYST, HOT EGR SCHEDULE A, MODIFIED AIR ENGINE 1-3, 23 MODE TEST

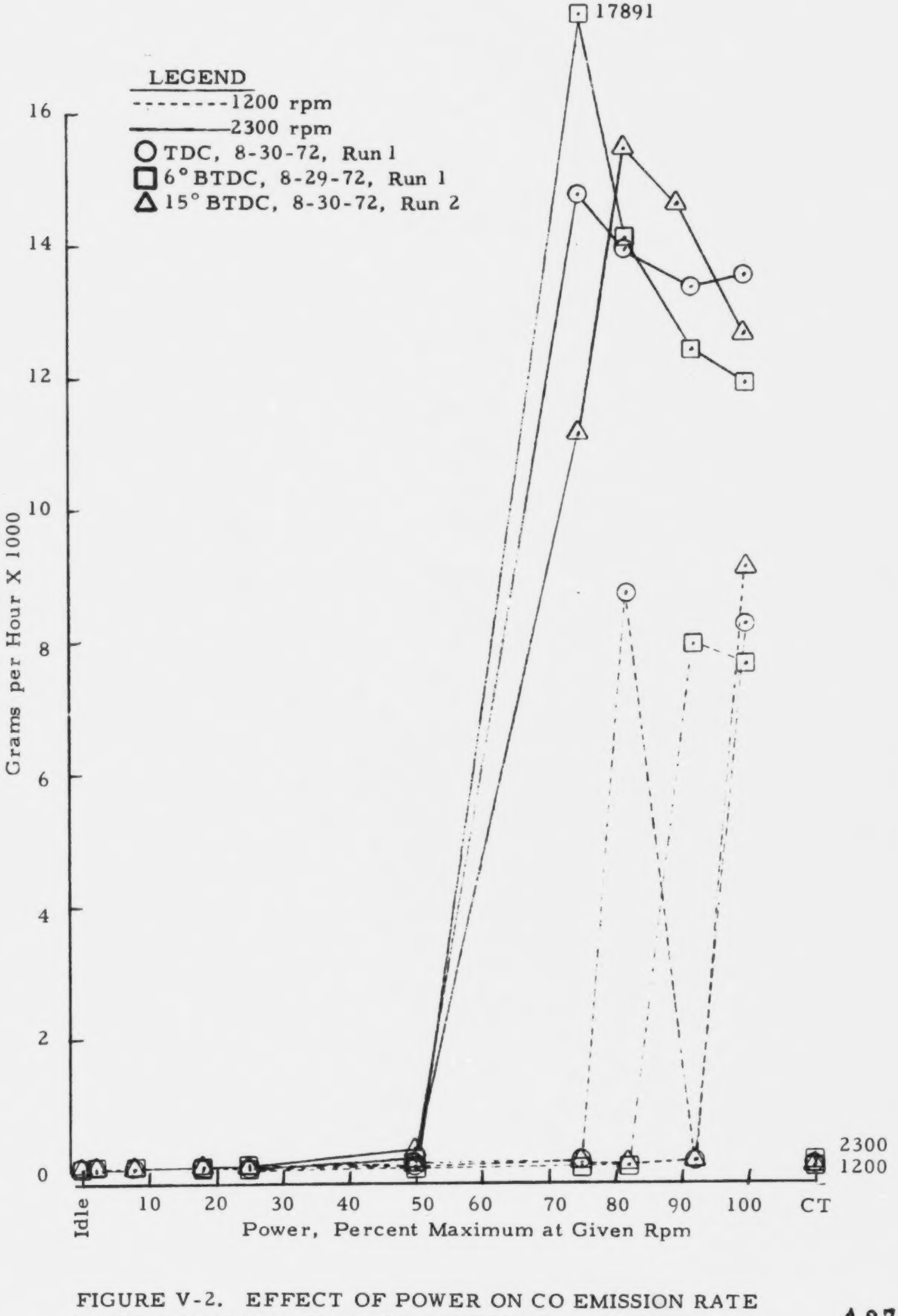


FIGURE V-2. EFFECT OF POWER ON CO EMISSION RATE AFTER CATALYST, HOT EGR SCHEDULE A, MODIFIED AIR ENGINE 1-3, 23 MODE TEST

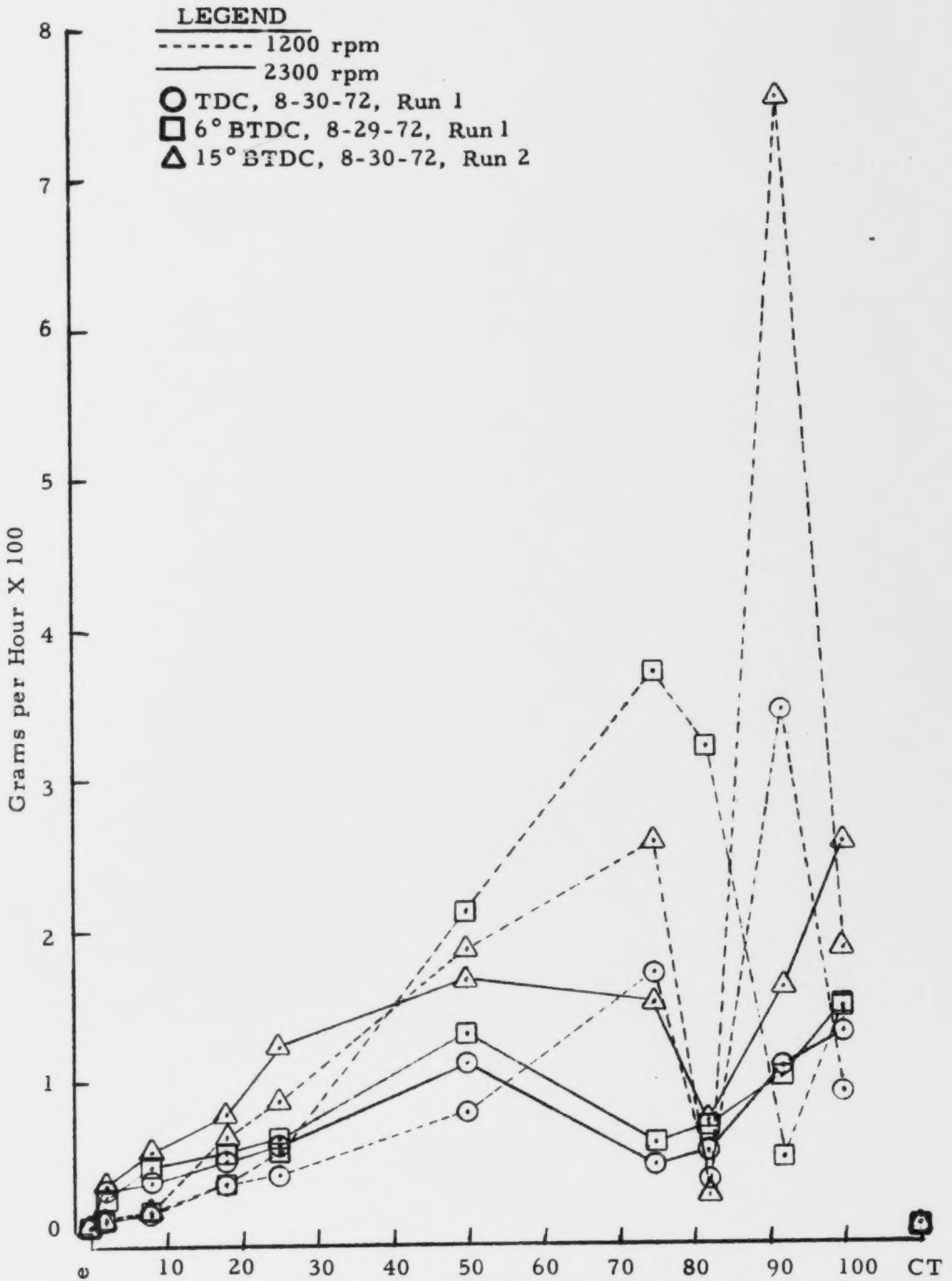


FIGURE V-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE AFTER CATALYST, HOT EGR SCHEDULE A, MODIFIED AIR ENGINE 1-3, 23 MODE TEST

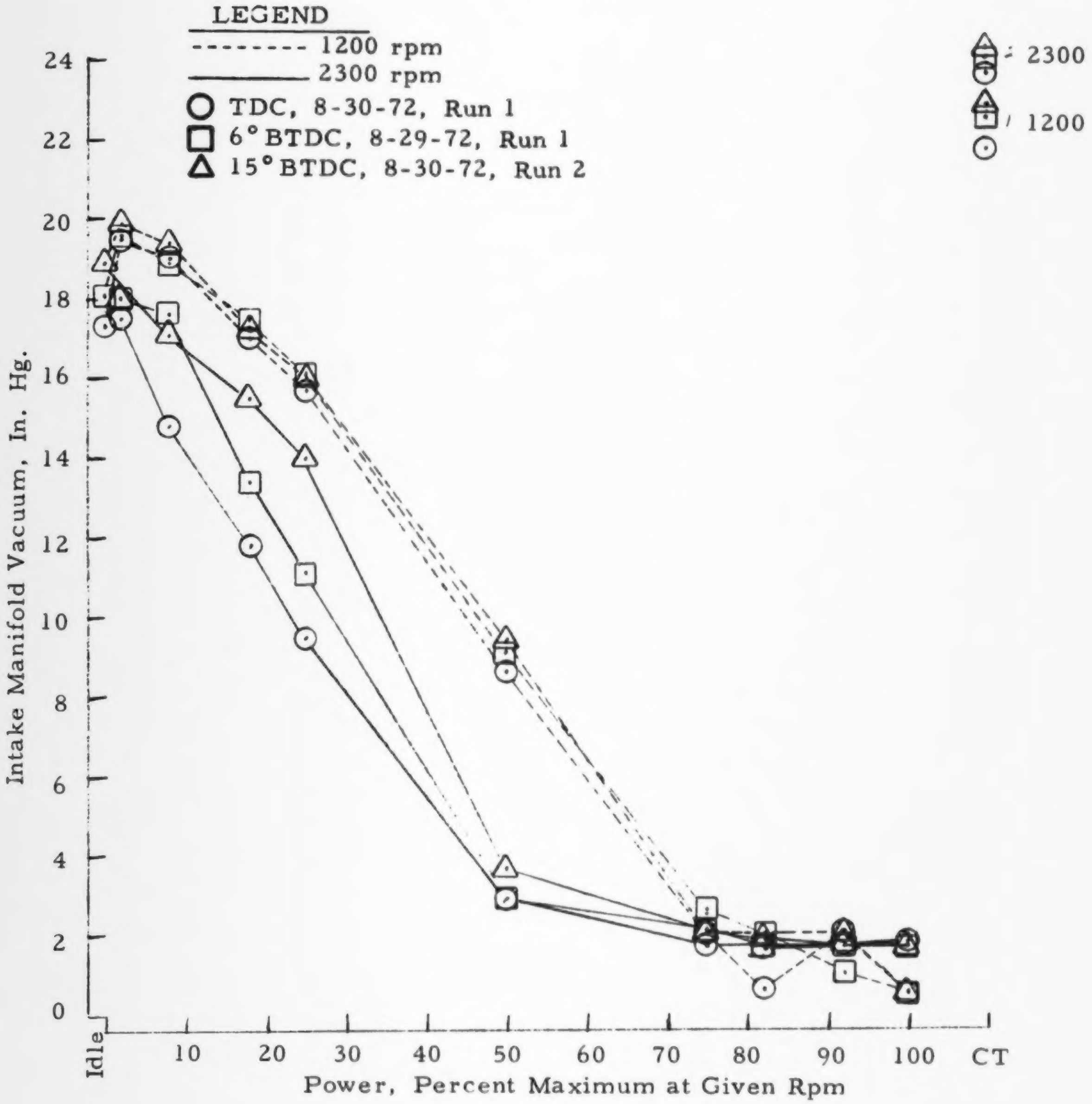


FIGURE V-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

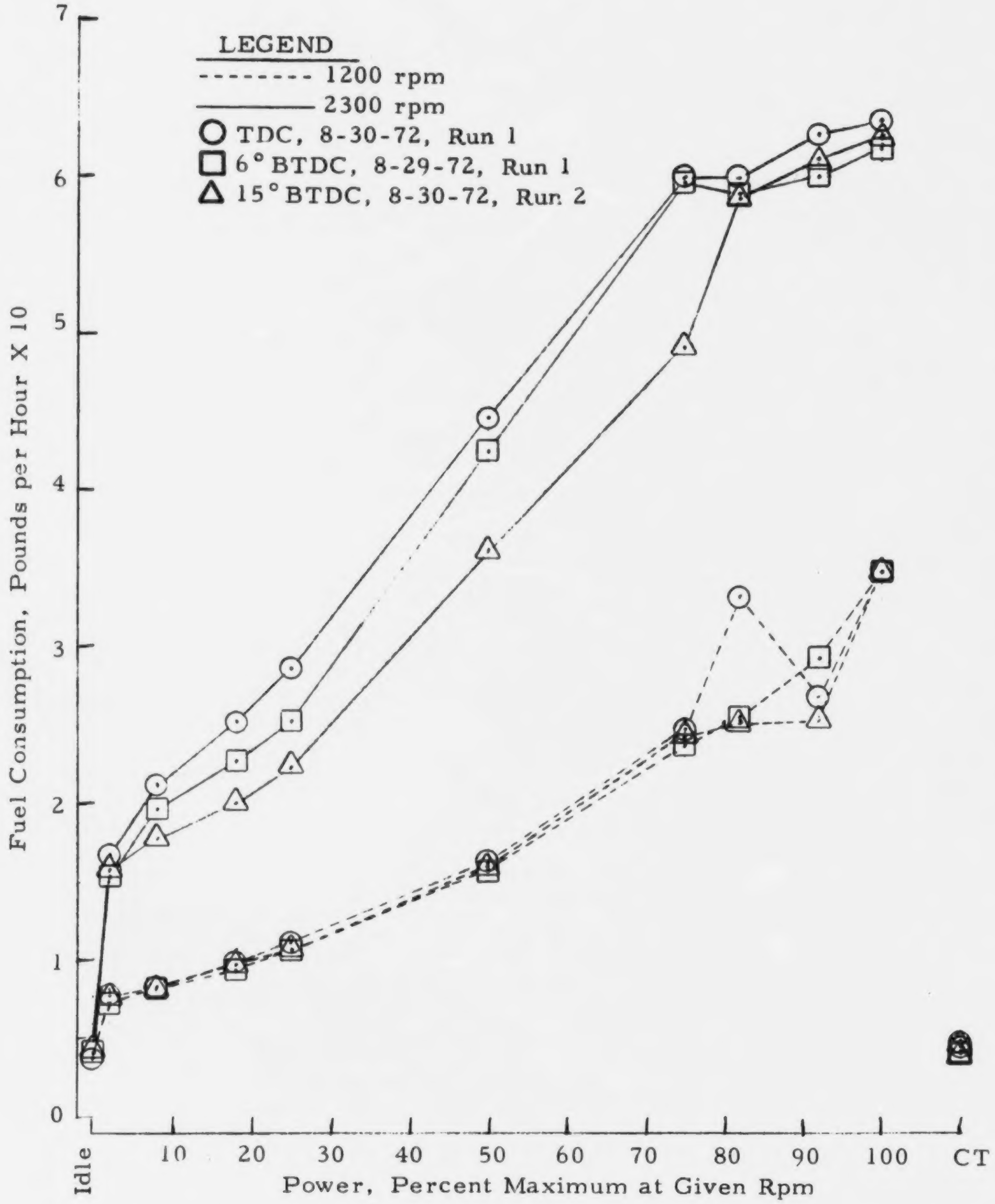


FIGURE V-5. FUEL CONSUMPTION AS A FUNCTION OF POWER
ENGINE 1-3, 23 MODE TEST

APPENDIX W

ENGINE 1-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

ENGINE 1-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

TABULAR 23 MODE DATA

BEFORE AND AFTER CATALYST

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
 9-05-72 RUN-1 ENG.1-3 72 VER.MODI AIR + EGR STD JETS + TIM B 0—CAT
--------------------------------------------------------------------------------
              DYNA.         MAN. FUEL     A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR   RATIO    ALDE.     HC      CO      CO2     NO
--------------------------------------------------------------------------------
  1   600      0.0     0   18.0   4.2    20.3        0   1769  1.200    10.25     37
  2  1200      4.0     1   19.7   7.8    22.9        0    454   .180    10.09     76
  3  1200     17.0     4   19.2   8.3    22.9        0    531   .180    10.09    121
  4  1200     39.0     9   17.7   9.3    21.9        0    781   .100    10.66    295
  5  1200     55.0    13   15.8  11.0    21.9        0    829   .100    10.55    385
  6  1200    109.0    25    9.5  15.8    21.3        0   1235   .070    11.01    570
  7  1200    164.0    37    2.3  23.7    19.2        0    519   .130    12.47   1087
  8  1200    179.0    41    1.8  25.2    17.4        0    383   .350    13.33    770
  9  1200    201.0    46    1.8  26.1    17.6        0    377   .350    13.06   1875
 10  1200    218.0    50     .5  34.8    13.7        0   1641  5.350    11.48    360
 11   600      0.0     0   18.3   4.3    19.0        0   1713  1.870    10.25    425
 12  1200      0.0     0   22.2   4.3    32.3        0  34299   .210     3.20     10
 13  2300    216.0    95    1.7  62.8    13.6        0    990  4.640    12.47    275
 14  2300    199.0    87    2.5  54.8    14.5        0    335  2.400    13.33    695
 15  2300    177.0    78    2.6  50.3    15.9        0     90   .890    12.94    620
 16  2300    162.0    71    2.7  48.2    16.9        0     84   .440    12.59    590
 17  2300    108.0    47    2.6  44.7    17.0        0    252   .390    12.47    190
 18  2300     54.0    24   11.5  25.4    23.3        0    661   .150     8.93    188
 19  2300     39.0    17   13.3  23.5    21.2        0    526   .130    10.25    163
 20  2300     17.0     7   15.9  18.8    21.1        0    496   .100    10.89    138
 21  2300      4.0     2   16.9  17.8    21.5        0    723   .150    10.09    127
 22   600      0.0     0   17.9   4.2    18.6        0   1936  1.520    10.66     42
 23  2300      0.0     0   23.6   4.5    32.3        0  52694   .070      .33      6
--------------------------------------------------------------------------------
           CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.        HP  ALDE.     HC       CO      NO2
--------------------------------------------------------------------------------
  1   0.0    29.0      397     2.0  .070       0.0              R        R        R
  2   0.0    15.6      125     8.7  .060        .1   0.0    17.05    136.5      9.5
  3   0.0    19.4      133    14.7  .060        .2   0.0     4.99     34.1      3.8
  4   0.0    30.4       79    38.1  .050        .4   0.0     3.41      8.8      4.3
  5   0.0    38.6       94    59.4  .030        .4   0.0     3.07      7.5      4.7
  6   0.0    79.0       90   121.1  .060       1.5   0.0     3.17      3.6      4.9
  7   0.0    44.1      223   306.8 0.000       0.0   0.0     1.18      6.0      8.2
  8   0.0    31.4      584   213.0  .040       1.6   0.0      .78     14.4      5.2
  9   0.0    33.2      622   548.0 0.000       0.0   0.0      .72     13.6     11.9
 10   0.0   152.4    10038   111.0 0.000       0.0   0.0     3.06    201.5      2.2
 11   0.0    27.2      599    22.4  .070       0.0     I        R        R        R
 12   0.0   978.1      121     1.0  .120       0.0     I        R        R        R
 13   0.0   163.4    15515   151.1  .025       2.4   0.0     1.73    164.0      1.6
 14   0.0    52.8     7645   363.9  .055       4.8   0.0      .61     87.7      4.2
 15   0.0    14.4     2964   339.4  .035       2.7   0.0      .19     38.2      4.4
 16   0.0    14.1     1490   328.5  .060       4.3   0.0      .20     21.0      4.6
 17   0.0    39.6     1240    99.3  .060       2.8   0.0      .84     26.2      2.1
 18   0.0    83.3      382    78.4 0.000       0.0   0.0     3.52     16.1      3.3
 19   0.0    53.8      268    55.1  .065       1.1   0.0     3.15     15.7      3.2
 20   0.0    38.3      156    35.3 0.000       0.0   0.0     5.14     21.0      4.7
 21   0.0    56.6      237    33.1 0.000       0.0   0.0    32.29    135.4     18.9
 22   0.0    29.8      473     2.1  .080       0.0     I        R        R        R
 23   0.0  1897.2       51      .6  .060       0.0     I        R        R        R

CYCLE COMPOSITE     HC      11.765    GRAM/BHP HR
                    CO      56.894    GRAM/BHP HR
                    NO2      3.936    GRAM/BHP HR
                    ALDE     0.000    GRAM/BHP HR
                    BSFC      .846      LB/BHP HR
```

```
                          PROJECT 11-2877-01  CONTROL TECHNOLOGY
  9-06-72 RUN-1 ENG.1-3 72 VER.MODI AIR HOT EGR STD JETS+TIM B O--CAT
------------------------------------------------------------------------------------
                  DYNA.         MAN. FUEL     A/F                DRY CONCENTRATION
MODE SPEED        LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC        CO        CO2      NO
------------------------------------------------------------------------------------
  1    600         0.0      0   17.7   4.0    19.3        0   1781     1.410     10.09      43
  2   1200         5.0      1   19.5   7.6    23.6        0    436      .130      9.64      54
  3   1200        18.0      4   18.6   8.6    23.5        0    687      .100      9.64     134
  4   1200        41.0      9   17.1   9.7    22.5        0    790      .070     10.43     225
  5   1200        57.0     13   15.0  11.5    22.5        0    931      .050     10.25     300
  6   1200       114.0     26    9.0  16.4    21.8        0   1351      .050     10.55     620
  7   1200       171.0     39    1.9  24.1    19.3        0    668      .130     11.92    1000
  8   1200       187.0     43    1.6  27.6    15.9        0    488     1.050     13.48     610
  9   1200       210.0     48    1.8  25.7    17.4        0    438      .310     12.94    1813
 10   1200       228.0     52     .5  34.3    13.7        0   1772     5.290     11.01     325
 11    600         0.0      0   17.9   4.1    19.6        0   1539     1.160     10.43      56
 12   1200         0.0      0   22.0   4.3    31.4        0  30302      .150      3.74      23
 13   2300       216.0     95    1.7  62.4    13.5        0   1040     4.450     12.34     230
 14   2300       199.0     87    2.5  54.1    14.6        0    223     1.840     13.48     680
 15   2300       177.0     78    2.7  49.6    15.7        0     76      .700     13.18     470
 16   2300       162.0     71    2.8  47.8    16.4        0     74      .350     12.94     555
 17   2300       108.0     47    2.7  43.6    16.9        0    738      .280     12.47     213
 18   2300        54.0     24   12.4  25.2    22.3        0    489      .130      9.25     205
 19   2300        39.0     17   13.9  22.4    22.4        0    435      .130      9.37     155
 20   2300        17.0      7   16.0  19.6    22.9        0    326      .100      9.14     142
 21   2300         4.0      2   17.2  17.4    23.6        0    758      .100      8.84     107
 22    600         0.0      0   17.8   4.0    20.4        0   1507      .740      9.64      61
 23   2300         0.0      0   23.4   4.4    35.6        0  55721      .070       .36       6
------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2   FAC.       HP  ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------
  1   0.0    27.7      443     2.2   .070      0.0      I       R        R        R
  2   0.0    15.3       92     6.3   .060       .1    0.0   13.41     80.7      5.5
  3   0.0    27.3       80    17.7   .060       .2    0.0    6.64     19.5      4.3
  4   0.0    32.9       59    31.1   .050       .5    0.0    3.51      6.3      3.3
  5   0.0    46.7       51    50.0   .030       .4    0.0    3.59      3.9      3.8
  6   0.0    93.6       70   142.6   .060      1.6    0.0    3.59      2.7      5.5
  7   0.0    60.3      237   299.5  0.000      0.0    0.0    1.54      6.1      7.7
  8   0.0    41.9     1821   173.9   .040      1.7    0.0     .98     42.6      4.1
  9   0.0    38.4      549   527.7  0.000      0.0    0.0     .80     11.4     11.0
 10   0.0   167.3    10090   101.9  0.000      0.0    0.0    3.21    193.7      2.0
 11   0.0    24.4      371     3.0   .070      0.0      I       R        R        R
 12   0.0   854.1       85     2.2   .120      0.0      I       R        R        R
 13   0.0   174.2    15060   127.9   .025      2.4    0.0    1.84    159.2      1.4
 14   0.0    35.6     5945   361.1   .055      4.8    0.0     .41     68.2      4.1
 15   0.0    12.3     2291   252.8   .035      2.7    0.0     .16     29.6      3.3
 16   0.0    12.1     1153   300.4   .060      4.3    0.0     .17     16.2      4.2
 17   0.0   113.8      872   109.1   .060      2.8    0.0    2.41     18.4      2.3
 18   0.0    59.3      318    82.5  0.000      0.0    0.0    2.51     13.5      3.5
 19   0.0    46.3      280    54.8   .065      1.1    0.0    2.71     16.4      3.2
 20   0.0    31.2      194    45.4  0.000      0.0    0.0    4.19     26.0      6.1
 21   0.0    66.3      177    31.2  0.000      0.0    0.0   37.88    101.0     17.8
 22   0.0    26.0      258     3.5   .080      0.0      I       R        R        R
 23   0.0  1852.4       47      .7   .060      0.0      I       R        R        R

CYCLE COMPOSITE     HC     11.082     GRAM/BHP HR
                    CO     49.101     GRAM/BHP HR
                    NO2     3.596     GRAM/BHP HR
                    ALDE    0.000     GRAM/BHP HR
                    BSFC     .833       LB/BHP HR
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  9-06-72 RUN-2 ENG.1-3 72 VER.MODI AIR HOT EGR STD JETS+TIM B O—CAT
------------------------------------------------------------------------------------------
             DYNA.         MAN.  FUEL      A/F
MODE SPEED    LOAD    HP   VAC. LB/HR    RATIO    ALDE.      DRY CONCENTRATION
                                                              HC        CO       CO2     NO
------------------------------------------------------------------------------------------
   1   600     0.0     0   17.7    4.0    18.2
   2  1200     5.0     1   19.6    7.6    23.2         0   1971    1.700      9.93     41
   3  1200    18.0     4   18.5    8.5    23.0         0    347     .100      9.03     56
   4  1200    41.0     9   16.9    9.6    22.8         0    678     .100      9.14    125
   5  1200    57.0    13   16.2   10.5    22.7         0    870     .070      9.37    250
   6  1200   114.0    26    9.5   15.8    22.1         0    926     .130      9.50    360
   7  1200   171.0    39    2.4   23.4    20.0         0   1460     .050      9.64    640
   8  1200   187.0    43    1.8   25.3    18.1         0    683     .050     11.01   1200
   9  1200   210.0    48    1.8   27.0    17.2         0    464     .250     11.92   1300
  10  1200   228.0    52     .5   33.4    13.6         0    430     .350     12.34   1862
  11   600     0.0     0   18.0    4.1    19.6         0   1678    5.140     11.01    380
  12  1200     0.0     0   22.0    4.3    28.1         0   1695    1.230      9.64     50
  13  2300   218.0    95    1.7   62.3    13.5         0  29589     .100      4.03      6
  14  2300   201.0    88    2.5   53.6    14.8         0    997    4.260     12.22    270
  15  2300   179.0    78    2.7   50.2    15.6         0    205    1.660     13.48    710
  16  2300   164.0    72    2.8   46.7    16.6         0     85     .700     13.18    610
  17  2300   109.0    48    2.7   43.4    16.4         0    119     .280     12.71    675
  18  2300    55.0    24   12.5   24.4    21.8         0    672     .280     12.71    215
  19  2300    39.0    17   14.2   21.7    22.2         0    468     .130      9.37    220
  20  2300    17.0     7   16.0   19.0    22.7         0    408     .130      9.37    175
  21  2300     4.0     2   17.2   17.2    24.0         0    347     .100      9.14    132
  22   600     0.0     0   17.7    4.0    20.1         0    757     .100      8.75    120
  23  2300     0.0     0   23.6    4.4    37.4         0   1644     .740      9.64     58
                                                       0  54170     .050       .29      7
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC      CO     NO2   FAC.     HP   ALDE.       HC       CO      NO2
------------------------------------------------------------------------------------------
   1   0.0    30.2     527     2.1   .070
   2   0.0    13.1      76     7.0   .060     0.0      I        R        R        R
   3   0.0    28.1      84    17.2   .060      .1    0.0    11.43     66.5      6.1
   4   0.0    39.8      65    37.9   .050      .2    0.0     6.83     20.3      4.2
   5   0.0    45.3     129    58.5   .030      .5    0.0     4.24      6.9      4.0
   6   0.0   106.4      74   154.8   .060      .4    0.0     3.48      9.9      4.5
   7   0.0    65.2      96   380.0  0.000     1.6    0.0     4.08      2.8      5.9
   8   0.0    43.6     474   405.4   .040     0.0    0.0     1.67      2.5      9.7
   9   0.0    41.4     680   594.8  0.000     1.7    0.0     1.02     11.1      9.5
  10   0.0   155.8    9640   117.1  0.000     0.0    0.0      .86     14.2     12.4
  11   0.0    28.6     419     2.8   .070     0.0    0.0     2.99    185.0      2.2
  12   0.0   814.1      56      .6   .120     0.0      I        R        R        R
  13   0.0   169.9   14667   152.8   .025     0.0      I        R        R        R
  14   0.0    32.9    5378   378.0   .055     2.4    0.0     1.78    153.6      1.6
  15   0.0    13.9    2318   332.0   .035     4.8    0.0      .37     61.1      4.3
  16   0.0    19.4     921   365.1   .060     2.7    0.0      .18     29.6      4.2
  17   0.0   101.3     853   107.6   .060     4.3    0.0      .27     12.8      5.1
  18   0.0    54.2     304    84.7  0.000     2.9    0.0     2.12     17.9      2.3
  19   0.0    42.1     271    59.9   .065     0.0    0.0     2.25     12.6      3.5
  20   0.0    32.3     188    40.9  0.000     1.1    0.0     2.46     15.9      3.5
  21   0.0    66.2     177    34.8  0.000     0.0    0.0     4.34     25.2      5.5
  22   0.0    28.3     257     3.3   .080     0.0    0.0    37.79    100.8     19.9
  23   0.0  1878.0      35      .7   .060     0.0      I        R        R        R
                                              0.0      I        R        R        R
CYCLE COMPOSITE    HC     10.890    GRAM/BHP HR
                   CO     44.193    GRAM/BHP HR
                   NO2     4.397    GRAM/BHP HR
                   ALDE    0.000    GRAM/BHP HR
                   BSFC     .813      LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
   9-05-72 RUN-1 ENG.1-3 72 VER.MODI AIR + EGR STD JETS + TIM A 0—CAT
--------------------------------------------------------------------------------
             DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED   LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC      CO      CO2     NO
--------------------------------------------------------------------------------
  1   600     0.0     0  18.0   4.2   21.6      15   359    .100   11.13     46
  2  1200     4.0     1  19.7   7.8   23.6      15   135    .020    9.93     95
  3  1200    17.0     4  19.2   8.3   23.5      14   156    .020    9.93    139
  4  1200    39.0     9  17.7   9.3   22.6      15   225    .020   10.43    270
  5  1200    55.0    13  15.8  11.0   22.5      22   228    .020   10.55    350
  6  1200   109.0    25   9.5  15.8   21.4      37   309    .020   11.01    495
  7  1200   164.0    37   2.3  23.7   19.3      41   222    .050   12.34   1013
  8  1200   179.0    41   1.8  25.2   17.6      34   196    .070   13.33    760
  9  1200   201.0    46   1.8  26.1   17.9      32   209    .070   13.06   1700
 10  1200   218.0    50    .5  34.8   13.9      34  1068   4.070   11.92    430
 11   600     0.0     0  18.3   4.3   19.5      26   353    .070   11.92     55
 12  1200     0.0     0  22.2   4.3   31.9      24  4567    .070    6.64     10
 13  2300   216.0    95   1.7  62.8   13.9      25   495   3.520   12.94    270
 14  2300   199.0    87   2.5  54.8   15.2      23    60    .670   13.91    715
 15  2300   177.0    78   2.6  50.3   16.9      20    50    .100   12.94    595
 16  2300   162.0    71   2.7  48.2   18.0      14    42    .100   12.22    595
 17  2300   108.0    47   2.6  44.7   18.1      14    40    .050   12.22    195
 18  2300    54.0    24  11.5  25.4   22.3      15   223    .050    9.50    179
 19  2300    39.0    17  13.3  23.5   20.9       6   147    .050   11.01    156
 20  2300    17.0     7  15.9  18.8   21.7       7   212    .050   10.43    123
 21  2300     4.0     2  16.9  17.8   22.1      18   355    .070    9.78    108
 22   600     0.0     0  17.9   4.2   19.8      12   291    .100   11.60     66
 23  2300     0.0     0  23.6   4.5   38.6      19   969    .210    4.94      5
--------------------------------------------------------------------------------
        CALCULATED GRAM/HR        WT.     WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC      CO     NO2  FAC.     HP  ALDE.     HC      CO     NO2
--------------------------------------------------------------------------------
  1    .5    6.1      34     2.6  .070    0.0      R      R       R       R
  2   1.1    4.8      14    11.2  .060     .1    1.2   5.26    15.7    12.3
  3   1.2    5.9      15    17.4  .060     .2     .3   1.52     3.9     4.5
  4   1.3    9.1      16    36.1  .050     .4     .1   1.02     1.8     4.1
  5   2.2   10.8      19    54.7  .030     .4     .2    .86     1.5     4.4
  6   5.1   20.0      26   106.5  .060    1.5     .2    .80     1.1     4.3
  7   7.7   19.2      87   291.3 0.000    0.0     .2    .51     2.3     7.8
  8   6.2   16.7     120   214.9  .040    1.6     .2    .41     2.9     5.3
  9   6.1   18.8     127   508.1 0.000    0.0     .1    .41     2.8    11.1
 10   7.3  104.7    8062   140.0 0.000    0.0     .1   2.10   161.9     2.8
 11    .9    5.7      23     3.0  .070    0.0      R      R       R       R
 12   1.4  124.3      38      .9  .120    0.0      R      R       R       R
 13   9.4   85.5   12269   154.7  .025    2.4     .1    .90   129.7     1.6
 14   8.6   10.3    2306   404.5  .055    4.8     .1    .12    26.5     4.6
 15   7.4    8.8     353   345.5  .035    2.7     .1    .11     4.6     4.5
 16   5.3    7.5     358   350.4  .060    4.3     .1    .11     5.1     4.9
 17   5.0    6.6     167   106.9  .060    2.8     .1    .14     3.5     2.3
 18   4.0   26.9     122    71.5 0.000    0.0     .2   1.14     5.1     3.0
 19   1.3   14.1      97    49.9  .065    1.1     .1    .83     5.7     2.9
 20   1.3   17.2      82    33.2 0.000    0.0     .2   2.31    11.0     4.5
 21   3.2   29.0     115    29.3 0.000    0.0    1.8  16.53    65.9    16.7
 22    .4    4.7      33     3.6  .080    0.0      R      R       R       R
 23   1.6   37.7     165      .6  .060    0.0      R      R       R       R

CYCLE COMPOSITE    HC       1.185   GRAM/BHP HR
                   CO      23.053   GRAM/BHP HR
                   NO2      4.027   GRAM/BHP HR
                   ALDE      .130   GRAM/BHP HR
                   BSFC      .846     LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
 9-06-72 RUN-1 ENG.1-3 72 VER.MODI AIR HOT EGR STD JETS+TIM A O—CAT
------------------------------------------------------------------------------------------
               DYNA.          MAN.  FUEL     A/F                  DRY CONCENTRATION
MODE SPEED     LOAD     HP    VAC.  LB/HR   RATIO     ALDE.      HC        CO       CO2      NO
------------------------------------------------------------------------------------------
  1    600      0.0      0    17.7    4.0    20.4        15      351     .020     11.13      53
  2   1200      5.0      1    19.5    7.6    24.5        15      163     .020      9.37      64
  3   1200     18.0      4    18.6    8.6    23.8        16      180     .020      9.78     143
  4   1200     41.0      9    17.1    9.7    23.4        16      235     .020      9.93     225
  5   1200     57.0     13    15.0   11.5    23.0        29      262     .020     10.09     290
  6   1200    114.0     26     9.0   16.4    21.9        34      382     .020     10.66     550
  7   1200    171.0     39     1.9   24.1    19.4        54      273     .020     12.22     980
  8   1200    187.0     43     1.6   27.6    16.1        35      309     .350     14.05     505
  9   1200    210.0     48     1.8   25.7    17.6        30      252     .020     13.18    1700
 10   1200    228.0     52      .5   34.3    13.8        46     1267    4.210     12.22     400
 11    600      0.0      0    17.9    4.1    20.3        22      329     .020     11.36      63
 12   1200      0.0      0    22.0    4.3    30.9        25     5533     .020      6.91      22
 13   2300    216.0     95     1.7   62.4    13.8        24      575    3.380     12.82     230
 14   2300    199.0     87     2.5   54.1    15.4        19       49     .180     14.18     690
 15   2300    177.0     78     2.7   49.6    16.7        23       39     .070     12.94     475
 16   2300    162.0     71     2.8   47.8    17.6        20       44     .050     12.47     570
 17   2300    108.0     47     2.7   43.6    17.6        13      122     .070     12.09     199
 18   2300     54.0     24    12.4   25.2    21.8        20      147     .050      9.64     200
 19   2300     39.0     17    13.9   22.4    22.2        10      120     .050      9.64     159
 20   2300     17.0      7    16.0   19.6    23.6        10      114     .050      8.93     130
 21   2300      4.0      2    17.2   17.4    26.9        19      387     .050      7.94      43
 22    600      0.0      0    17.8    4.0    21.0        14      274     .050     10.25      71
 23   2300      0.0      0    23.4    4.4    43.5        14      678     .180      4.54       4
------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR             WT.      WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.      HC       CO      NO2   FAC.      HP   ALDE.      HC       CO      NO2
------------------------------------------------------------------------------------------
  1     .5     5.7        7      2.9   .070     0.0       R        R        R        R
  2    1.2     6.0       15      7.8   .060      .1     1.1     5.23     13.0      6.8
  3    1.4     7.2       16     18.9   .060      .2      .3     1.74      3.9      4.6
  4    1.5    10.4       18     33.0   .050      .5      .2     1.11      1.9      3.5
  5    3.2    13.5       21     49.5   .030      .4      .2     1.04      1.6      3.8
  6    5.2    26.5       28    126.7   .060     1.6      .2     1.02      1.1      4.9
  7   10.4    24.3       36    289.9  0.000     0.0      .3      .62       .9      7.4
  8    6.5    26.8      613    145.5   .040     1.7      .2      .63     14.4      3.4
  9    5.6    22.3       36    497.5  0.000     0.0      .1      .46       .7     10.4
 10    9.2   119.1     7991    124.8  0.000     0.0      .2     2.29    153.4      2.4
 11     .8     5.4        7      3.4   .070     0.0       R        R        R        R
 12    1.4   144.2       11      1.9   .120     0.0       R        R        R        R
 13    8.9   100.1    11887    132.9   .025     2.4      .1     1.06    125.7      1.4
 14    6.9     8.3      621    391.3   .055     4.8      .1      .10      7.1      4.5
 15    8.6     6.8      244    272.6   .035     2.7      .1      .09      3.2      3.5
 16    7.6     7.5      175    327.6   .060     4.3      .1      .11      2.5      4.6
 17    4.5    19.9      230    107.3   .060     2.8      .1      .42      4.9      2.3
 18    5.0    17.3      119     78.2  0.000     0.0      .2      .73      5.0      3.3
 19    2.2    12.6      106     55.3   .065     1.1      .1      .73      6.2      3.2
 20    2.1    11.2      100     42.7  0.000     0.0      .3     1.51     13.4      5.7
 21    3.9    38.0       99     14.0  0.000     0.0     2.3    21.70     56.7      8.0
 22     .5     4.8       18      4.1   .080     0.0       R        R        R        R
 23    1.2    28.3      152       .6   .060     0.0       R        R        R        R

CYCLE COMPOSITE   HC      1.341   GRAM/BHP HR
                  CO     18.352   GRAM/BHP HR
                  NO2     3.697   GRAM/BHP HR
                  ALDE     .135   GRAM/BHP HR
                  BSFC     .833     LB/BHP HR
```

```
                    PROJECT 11-2877-01  CONTROL TECHNOLOGY
  9-06-72 RUN-2 ENG.1-3 72 VER.MODI AIR HOT EGR STD JETS+TIM A O--CAT
--------------------------------------------------------------------------------
              DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED    LOAD    HP   VAC. LB/HR  RATIO   ALDE.     HC       CO      CO2     NO
--------------------------------------------------------------------------------
  1    600     0.0     0  17.7    4.0   19.4       19    374    .020    11.36     50
  2   1200     5.0     1  19.6    7.6   23.9       14    114    .020     8.93     65
  3   1200    18.0     4  18.5    8.5   23.9       15    184    .020     9.03    131
  4   1200    41.0     9  16.9    9.6   23.7       15    242    .020     9.14    230
  5   1200    57.0    13  16.2   10.5   23.8       27    258    .020     9.14    330
  6   1200   114.0    26   9.5   15.8   22.4       31    392    .020     9.64    580
  7   1200   171.0    39   2.4   23.4   20.1       45    268    .020    11.01   1138
  8   1200   187.0    43   1.8   25.3   18.5       37    250    .020    11.92   1213
  9   1200   210.0    48   1.8   27.0   17.6       34    254    .020    12.34   1725
 10   1200   228.0    52    .5   33.4   13.9       38   1181   3.890    11.92    430
 11    600     0.0     0  18.0    4.1   20.8       26    324    .020    10.55     65
 12   1200     0.0     0  22.0    4.3   29.7       20   5198    .020     6.56     12
 13   2300   218.0    95   1.7   62.3   13.9       21    482   3.100    12.82    300
 14   2300   201.0    88   2.5   53.6   15.7       22     61    .150    13.91    720
 15   2300   179.0    78   2.7   50.2   16.5       21     55    .070    12.94    570
 16   2300   164.0    72   2.8   46.7   17.7       16     60    .050    11.92    670
 17   2300   109.0    48   2.7   43.4   17.4       10    109    .070    12.22    210
 18   2300    55.0    24  12.5   24.4   21.4       15    131    .050     9.93    210
 19   2300    39.0    17  14.2   21.7   22.3        8    123    .050     9.37    169
 20   2300    17.0     7  16.0   19.0   23.4        8    135    .050     8.93    119
 21   2300     4.0     2  17.2   17.2   24.6       19    335    .050     8.60     98
 22    600     0.0     0  17.7    4.0   21.0       11    310    .050    10.09     69
 23   2300     0.0     0  23.6    4.4   46.7       15   1351    .150     4.11      4
--------------------------------------------------------------------------------
         CALCULATED GRAM/HR         WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO     NO2  FAC.      HP  ALDE.     HC       CO     NO2
--------------------------------------------------------------------------------
  1     .7     5.9       6     2.6  .070     0.0     R        R        R       R
  2    1.2     4.4      16     8.3  .060      .1   1.0     3.83     13.6     7.3
  3    1.4     7.8      17    18.5  .060      .2    .3     1.90      4.2     4.5
  4    1.6    11.5      19    36.2  .050      .5    .2     1.22      2.0     3.9
  5    3.0    13.4      21    56.8  .030      .4    .2     1.03      1.6     4.4
  6    5.0    29.0      30   142.3  .060     1.6    .2     1.11      1.1     5.5
  7    9.4    25.7      39   362.7 0.000     0.0    .2      .66      1.0     9.3
  8    7.6    24.0      39   386.3  .040     1.7    .2      .56       .9     9.0
  9    7.2    25.1      40   566.3 0.000     0.0    .2      .52       .8    11.8
 10    7.8   112.3    7474   135.8 0.000     0.0    .1     2.16    143.5     2.6
 11    1.0     5.7       7     3.8  .070     0.0     R        R        R       R
 12    1.2   142.8      11     1.1  .120     0.0     R        R        R       R
 13    7.9    85.3   11082   176.3  .025     2.4    .1      .89    116.1     1.8
 14    8.3    10.5     524   413.2  .055     4.8    .1      .12      5.9     4.7
 15    7.8     9.6     247   331.1  .035     2.7    .1      .12      3.2     4.2
 16    6.0    10.6     179   393.5  .060     4.3    .1      .15      2.5     5.5
 17    3.5    17.5     226   111.6  .060     2.9    .1      .37      4.7     2.3
 18    3.7    14.5     112    77.2 0.000     0.0    .2      .60      4.6     3.2
 19    1.8    12.8     105    58.6  .065     1.1    .1      .75      6.2     3.4
 20    1.7    13.0      97    37.9 0.000     0.0    .2     1.74     13.0     5.1
 21    3.6    30.1      91    29.2 0.000     0.0   2.1    17.17     51.8    16.7
 22     .4     5.5      18     4.1  .080     0.0     R        R        R       R
 23    1.5    61.4     138      .6  .060     0.0     R        R        R       R

CYCLE COMPOSITE    HC      1.412   GRAM/BHP HR
                   CO     16.057   GRAM/BHP HR
                   NO2     4.532   GRAM/BHP HR
                   ALDE     .129   GRAM/BHP HR
                   BSFC     .813     LB/BHP HR
```

ENGINE 1-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

GRAPHED RESULTS OF 23 MODE TESTS

(AFTER CATALYST)

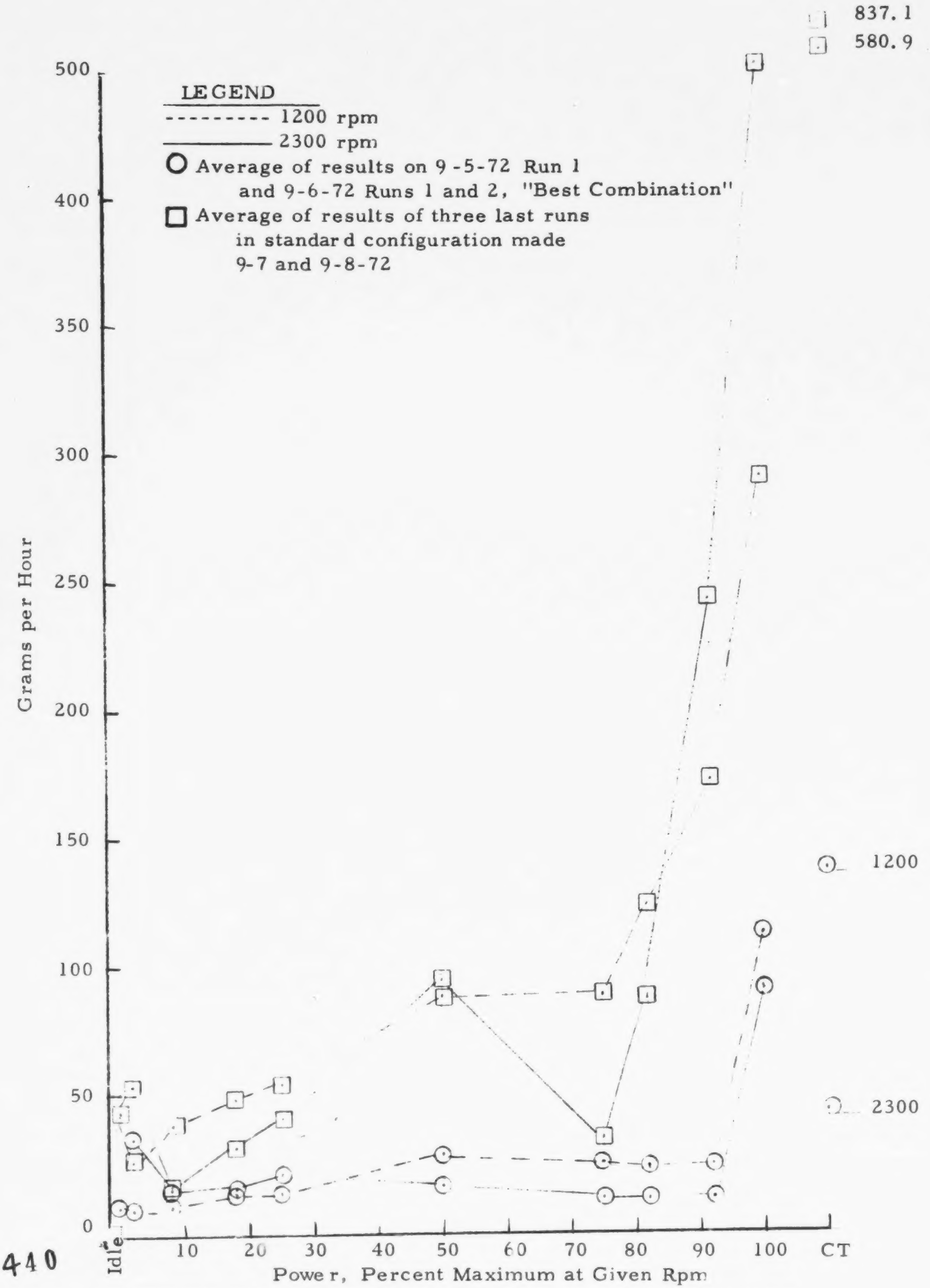


FIGURE W-1. EFFECT OF POWER ON HC EMISSION RATE
"BEST COMBINATION"
ENGINE 1-3, 23 MODE TEST

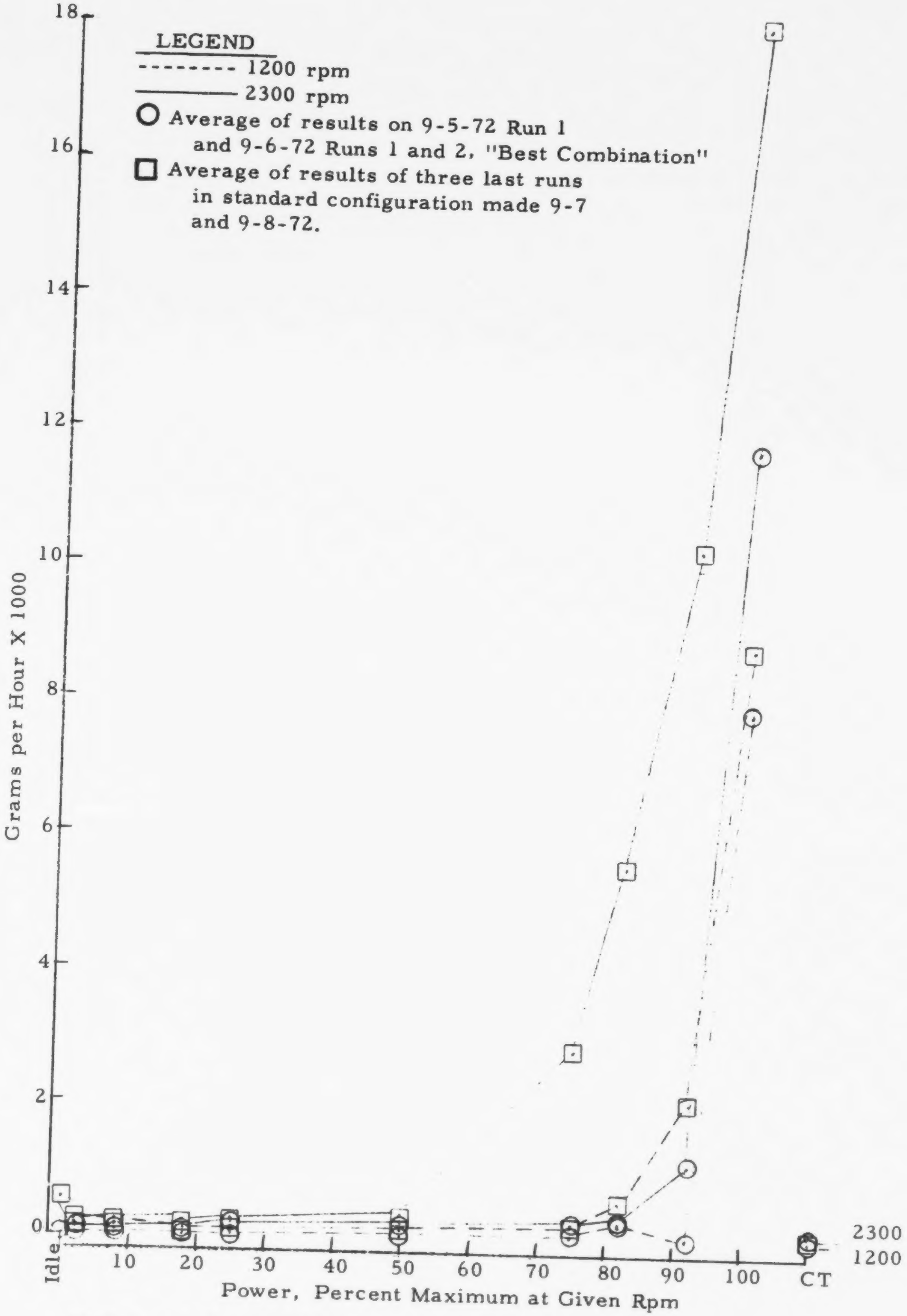


FIGURE W-2. EFFECT OF POWER ON CO EMISSION RATE "BEST COMBINATION" ENGINE 1-3, 23 MODE TEST

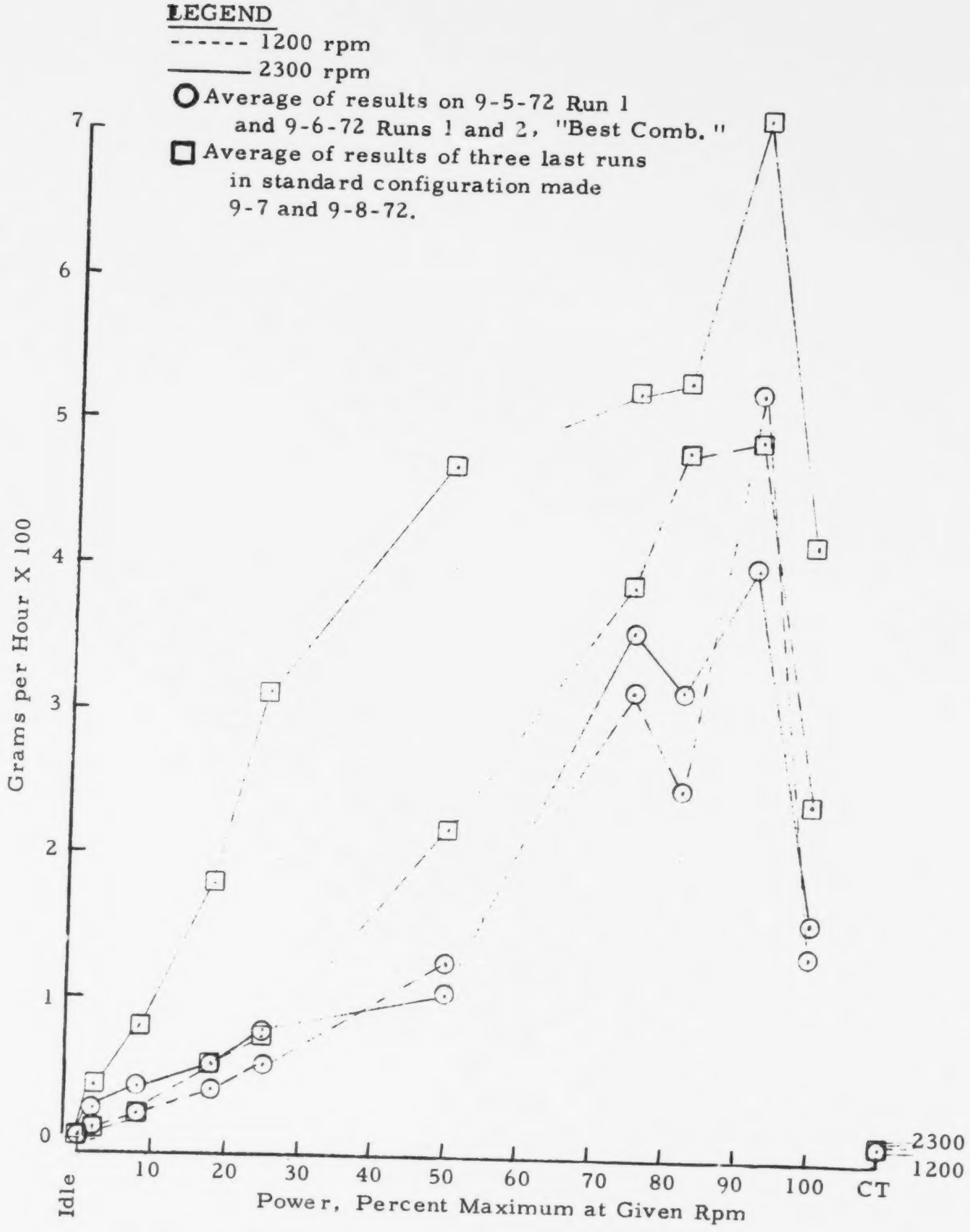


FIGURE W-3. EFFECT OF POWER ON NO_x (AS NO_2) EMISSION RATE "BEST COMBINATION" ENGINE 1-3, 23 MODE TEST

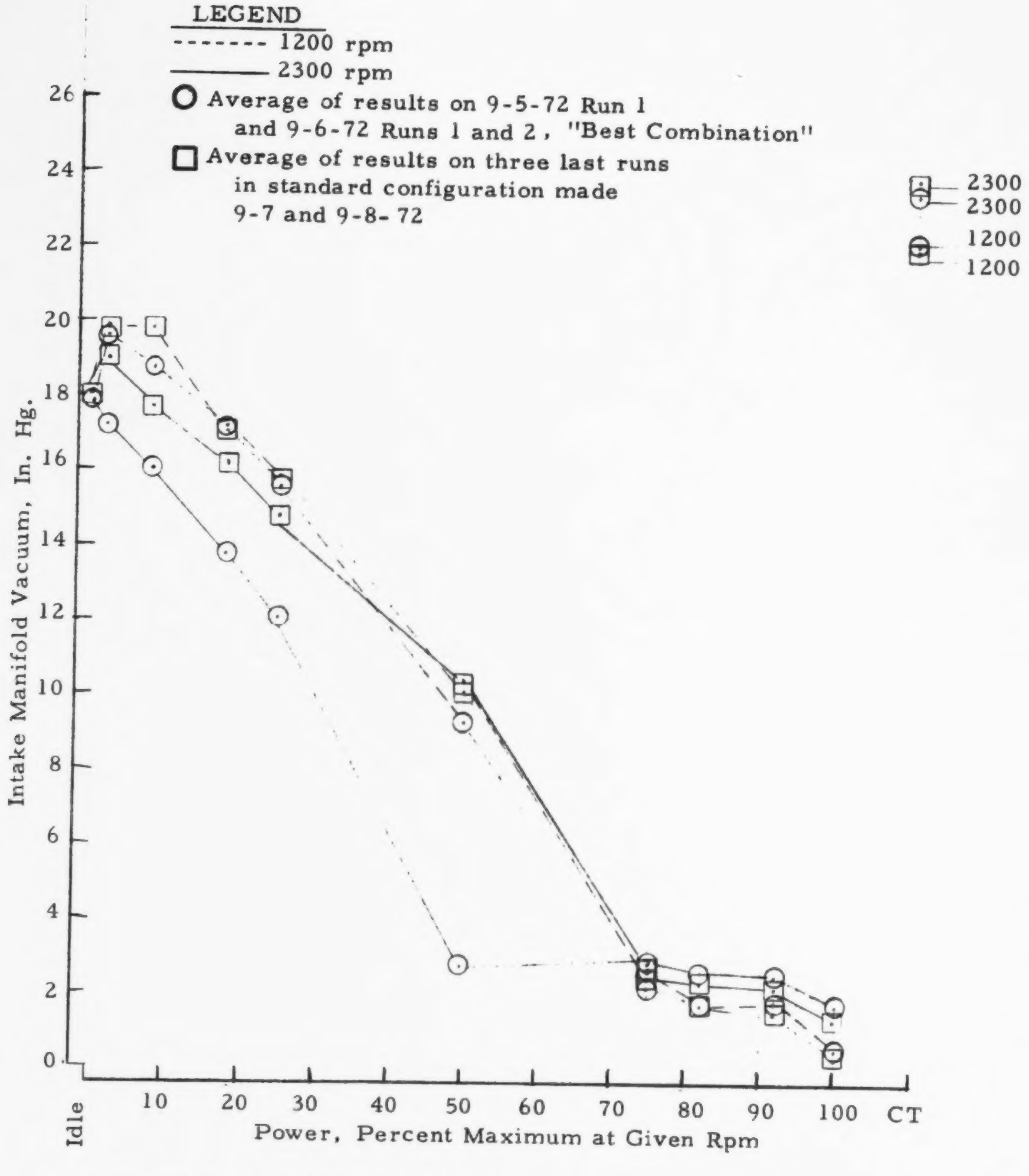


FIGURE W-4. MANIFOLD VACUUM AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

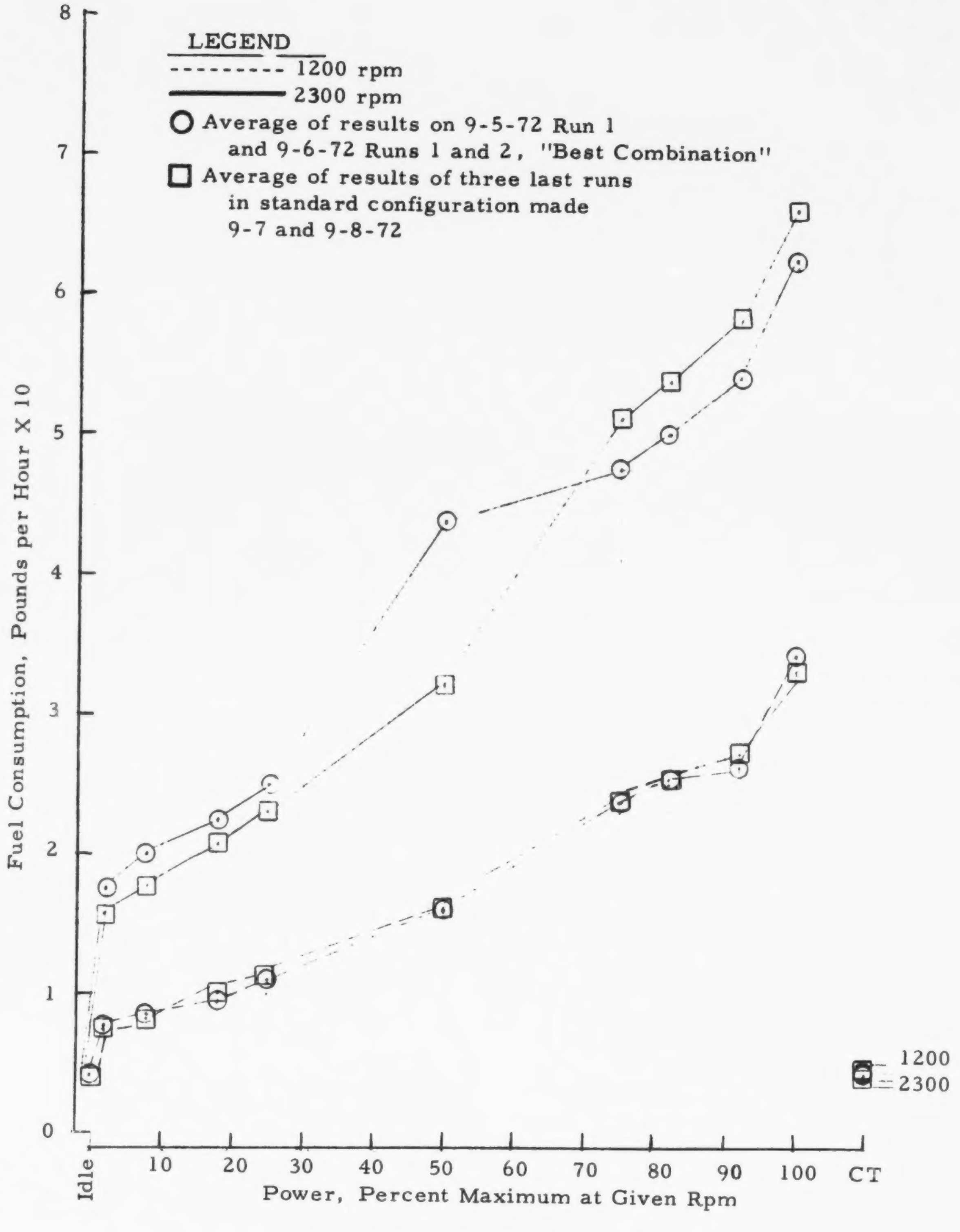


FIGURE W-5. FUEL CONSUMPTION AS A FUNCTION OF POWER ENGINE 1-3, 23 MODE TEST

ENGINE 1-3

EFFECT OF "BEST COMBINATION" ON EMISSIONS

TABULAR NINE-MODE FTP DATA

CONCENTRATION AND CALIFORNIA ARB MASS

```
    9-1-72      1-3                RUN 1                                         K =1.038     HUM =  86  GR/LB
    ---------------------------------------------------------------------------------------------------------------
    FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D     WEIGHTING       W E I G H T E D
    MODE           HC     CO     CO2     NO      FACTOR      HC     CO    NO       FACTOR        HC      CO       NO
    ---------------------------------------------------------------------------------------------------------------
CYCLE 1
    1 IDLE         46   .045  11.750     77      1.227       56   .055    94       .036        2.031   .002     3.400
    2 16'HG       340   .052   9.640     90      1.445      491   .075   130       .089       43.732   .007    11.576
    3 10'HG        37   .054  11.790    628      1.223       45   .066   768       .257       11.629   .017   197.373
    4 16'HG        30   .029  10.190    438      1.416       42   .041   620       .089        3.782   .004    55.216
    5 19'HG        31   .025   8.980    152      1.606       50   .040   244       .047        2.341   .002    11.477
    6 16'HG        32   .030  10.350    493      1.394       45   .042   687       .089        3.971   .004    61.177
    7  3'HG        29   .069  12.830    597      1.124       33   .078   671       .283        9.228   .022   189.968
    8 16'HG        29   .032  10.510    582      1.373       40   .044   799       .089        3.545   .004    71.142
    9 C.T.        427   .094   6.440     91      2.087      891   .196   190       .021       18.713   .004     3.988
    SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------   98.971   .065   605.316
CYCLE 2
    1 IDLE         46   .045  11.750     77      1.227       56   .055    94       .036        2.031   .002     3.400
    2 16'HG        35   .023  10.290    400      1.402       49   .032   561       .089        4.369   .003    49.926
    3 10'HG        39   .034  11.760    567      1.227       48   .042   696       .257       12.296   .011   178.772
    4 16'HG        34   .021  10.510    478      1.373       47   .029   657       .089        4.156   .003    58.430
    5 19'HG        45   .022   9.030    169      1.595       72   .035   270       .047        3.374   .002    12.671
    6 16'HG        35   .025  10.670    512      1.353       47   .034   693       .089        4.213   .003    61.634
    7  3'HG        31   .051  12.280    700      1.175       36   .060   823       .283       10.309   .017   232.795
    8 16'HG        31   .023  10.290    562      1.403       43   .032   788       .089        3.871   .003    70.175
    9 C.T.        384   .082   6.260     89      2.159      829   .177   192       .021       17.411   .004     4.035
    SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------   62.031   .046   671.838
CYCLE 3
    1 IDLE         41   .020  11.530    211      1.252       51   .025   264       .036        1.848   .001     9.508
    2 16'HG        34   .022  10.180    515      1.418       48   .031   730       .089        4.290   .003    64.981
    3 10'HG        27   .031  11.350    472      1.273       34   .039   601       .257        8.830   .010   154.362
    4 16'HG        27   .020   9.980    547      1.447       39   .029   792       .089        3.478   .003    70.455
    5 19'HG        28   .020   8.840    183      1.633       46   .033   299       .047        2.149   .002    14.044
    6 16'HG        29   .020  10.280    532      1.405       41   .028   747       .089        3.626   .003    66.517
    7  3'HG        28   .048  12.230    695      1.180       33   .057   820       .283        9.353   .016   232.162
    8 16'HG        27   .020  10.420    582      1.386       37   .028   807       .089        3.331   .002    71.810
    9 C.T.        364   .070   6.260    110      2.168      789   .152   238       .021       16.572   .003     5.008
    SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------   53.477   .042   688.848
CYCLE 4
    1 IDLE         41   .020  11.530    211      1.252       51   .025   264       .036        1.848   .001     9.508
    2 16'HG        33   .020  10.110    552      1.428       47   .029   788       .089        4.193   .003    70.144
    3 10'HG        36   .033  11.550    514      1.249       45   .041   642       .257       11.560   .011   165.046
    4 16'HG        33   .020   9.970    522      1.448       48   .029   756       .089        4.252   .003    67.259
    5 19'HG        54   .020   8.730    183      1.648       89   .033   302       .047        4.183   .002    14.175
    6 16'HG        35   .021  10.120    552      1.426       50   .030   787       .089        4.442   .003    70.057
    7  3'HG        29   .044  12.220    674      1.181       34   .052   796       .283        9.696   .015   225.347
    8 16'HG        36   .020   9.770    628      1.477       53   .030   927       .089        4.731   .003    82.538
    9 C.T.        332   .064   5.640    127      2.404      798   .154   305       .021       16.764   .003     6.413
    SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------   61.668   .041   710.486

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)------------------------------------   80.501   .056   638.577

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)------------------------------------   57.573   .042   699.667

    FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(   80.501) + 0.65*(   57.573) =    65.598  PPM
                                                CO    0.35*(     .056) + 0.65*(     .042) =      .047  PERCENT
                                                NO    0.35*(  638.577) + 0.65*(  699.667) =   678.286  PPM
                                                                          CORRECTED NO =   704.040  PPM

    DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
                                                                         K =1.038     HUM =  86   GR/LB
  9-1-72      1-3                   RUN 2                                                                   
----------------------------------------------------------------------------------------------------------------
FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D   WEIGHTING       W E I G H T E D
MODE            HC      CO     CO2     NO     FACTOR     HC     CO    NO       FACTOR       HC       CO        NO
----------------------------------------------------------------------------------------------------------------
CYCLE 1
  1 IDLE        45    .053  12.090    109     1.192      54   .063    130      .036       1.931    .002      4.677
  2 16'HG       30    .056  10.990    386     1.312      39   .073    506      .089       3.503    .007     45.078
  3 10'HG       31    .072  12.470    628     1.156      36   .083    726      .257       9.213    .021    186.630
  4 16'HG       26    .052  10.870    567     1.327      35   .069    753      .089       3.071    .006     66.982
  5 19'HG       27    .052   9.720    175     1.483      40   .077    260      .047       1.882    .004     12.201
  6 16'HG       31    .066  11.730    542     1.229      38   .081    666      .089       3.391    .007     59.293
  7  3'HG       24    .197  13.510    666     1.063      26   .210    708      .283       7.223    .059    200.444
  8 16'HG       42    .052  10.360    674     1.390      58   .072    937      .089       5.196    .006     83.383
  9 C.T.       367    .100   6.201     75     2.182     801   .218    164      .021      16.814    .005      3.436
  SUM-----------(CYCLE COMPOSITE)----------------------------------------------------     52.225    .118    662.123
CYCLE 2
  1 IDLE        45    .053  12.090    109     1.192      54   .063    130      .036       1.931    .002      4.677
  2 16'HG       32    .049  10.720    478     1.345      43   .066    643      .089       3.831    .006     57.228
  3 10'HG       12    .062  12.060    567     1.198      14   .074    679      .257       3.694    .019    174.565
  4 16'HG       10    .047  10.580    552     1.366      14   .064    754      .089       1.216    .006     67.113
  5 19'HG       12    .041   9.300    170     1.554      19   .064    264      .047        .876    .003     12.413
  6 16'HG       17    .048  11.110    507     1.300      22   .062    654      .089       1.967    .006     58.205
  7  3'HG       19    .067  13.010    705     1.110      21   .074    782      .283       5.968    .021    221.445
  8 16'HG       34    .045  10.110    579     1.426      48   .064    826      .089       4.315    .006     73.477
  9 C.T.       318    .087   5.940     72     2.292     729   .199    165      .021      15.305    .004      3.465
  SUM-----------(CYCLE COMPOSITE)----------------------------------------------------     39.103    .072    672.587
CYCLE 3
  1 IDLE        33    .044  12.020    107     1.201      40   .053    128      .036       1.426    .002      4.625
  2 16'HG       23    .049  11.330    365     1.274      29   .062    465      .089       2.608    .006     41.394
  3 10'HG       19    .049  10.960    493     1.318      25   .065    650      .257       6.434    .017    166.939
  4 16'HG       20    .044   9.750    552     1.481      30   .065    817      .089       2.635    .006     72.737
  5 19'HG       19    .041   9.470    157     1.525      29   .063    239      .047       1.361    .003     11.250
  6 16'HG       21    .063  11.950    559     1.208      25   .076    675      .089       2.258    .007     60.095
  7  3'HG       19    .061  12.710    689     1.136      22   .069    783      .283       6.110    .020    221.558
  8 16'HG       80    .044   9.350    582     1.533     123   .067    892      .089      10.915    .006     79.408
  9 C.T.       303    .079   5.810     62     2.348     711   .185    146      .021      14.937    .004      3.056
  SUM-----------(CYCLE COMPOSITE)----------------------------------------------------     48.685    .069    661.061
CYCLE 4
  1 IDLE        33    .044  12.020    107     1.201      40   .053    128      .036       1.426    .002      4.625
  2 16'HG       28    .042  10.710    498     1.347      38   .057    671      .089       3.358    .005     59.721
  3 10'HG       29    .054  11.940    537     1.209      35   .065    649      .257       9.007    .017    166.784
  4 16'HG       27    .044  10.470    522     1.378      37   .061    719      .089       3.312    .005     64.027
  5 19'HG       38    .042   9.190    157     1.567      60   .066    246      .047       2.799    .003     11.565
  6 16'HG       27    .045  10.620    569     1.359      37   .061    773      .089       3.265    .005     68.808
  7  3'HG       25    .066  12.600    705     1.145      29   .076    807      .283       8.103    .021    228.512
  8 16'HG       28    .049  10.400    625     1.387      39   .068    867      .089       3.456    .006     77.148
  9 C.T.       322    .088   5.860     59     2.319     747   .204    137      .021      15.683    .004      2.874
  SUM-----------(CYCLE COMPOSITE)----------------------------------------------------     50.410    .069    684.063

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)--------------------------------     45.664    .095    667.355

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)--------------------------------     49.547    .069    672.562

  FOUR CYCLE COMPOSITE - REPORTED VALUES -   HC   0.35*(   45.664) + 0.65*(   49.547) =    48.188  PPM
                                             CO   0.35*(     .095) + 0.65*(     .069) =      .078  PERCENT
                                             NO   0.35*(  667.355) + 0.65*(  672.562) =   670.740  PPM
                                                                     CORRECTED NO =   696.208  PPM

  DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
     9-5-72      1-3              RUN I                                           K = .752     HUM =  21   GR/LB
    ------------------------------------------------------------------------------------------------------------------
    FEDERAL      CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D    WEIGHTING        W E I G H T E D
    MODE             HC      CO     CO2      NO    FACTOR      HC      CO     NO      FACTOR        HC       CO        NO
    ------------------------------------------------------------------------------------------------------------------
CYCLE 1
    1 IDLE           38    .021  11.290      78     1.225      47    .026     96       .036      1.675     .001     3.438
    2 16'HG          25    .020  10.200     330     1.416      35    .028    467       .089      3.152     .003    41.601
    3 10'HG          27    .030  11.370     572     1.270      34    .038    727       .257      8.815     .010   186.747
    4 16'HG          21    .020   9.920     399     1.457      31    .029    581       .089      2.723     .003    51.736
    5 19'HG          20    .020   8.850     130     1.633      33    .033    212       .047      1.535     .002     9.975
    6 16'HG          22    .020   9.920     402     1.457      32    .029    586       .089      2.852     .003    52.119
    7  3'HG          23    .049  12.020     587     1.201      28    .059    705       .283      7.820     .017   199.576
    8 16'HG          28    .020   9.950     459     1.451      41    .029    666       .089      3.617     .003    59.292
    9 C.T.          264    .073   6.000      47     2.294     606    .167    108       .021     12.716     .004     2.264
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     44.905     .043   606.748
CYCLE 2
    1 IDLE           38    .021  11.790      78     1.225      47    .026     96       .036      1.675     .001     3.438
    2 16'HG          13    .022  11.000     377     1.315      17    .029    496       .089      1.522     .003    44.129
    3 10'HG          10    .021  10.910     373     1.326      13    .028    495       .257      3.409     .007   127.156
    4 16'HG           9    .020   9.180     458     1.576      14    .032    722       .089      1.262     .003    64.246
    5 19'HG          10    .020   9.750     156     1.484      15    .030    232       .047       .697     .001    10.881
    6 16'HG          32    .047  11.250     405     1.282      41    .060    519       .089      3.652     .005    46.219
    7  3'HG           9    .143  12.960     612     1.112      10    .159    680       .283      2.832     .045   192.570
    8 16'HG         278    .020   7.630     527     1.826     508    .037    962       .089     45.182     .003    85.652
    9 C.T.          272    .071   6.040      52     2.277     619    .162    118       .021     13.004     .003     2.486
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     73.236     .072   576.777
CYCLE 3
    1 IDLE           28    .020  11.800     183     1.225      34    .024    224       .036      1.234     .001     8.068
    2 16'HG          20    .021  10.010     348     1.444      29    .030    502       .089      2.570     .003    44.721
    3 10'HG          21    .022  11.140     377     1.298      27    .029    489       .257      7.004     .007   125.732
    4 16'HG          19    .020   9.420     478     1.534      29    .031    733       .089      2.595     .003    65.272
    5 19'HG          21    .020   8.810     183     1.640      34    .033    300       .047      1.618     .002    14.104
    6 16'HG          24    .024  10.720     512     1.348      32    .032    690       .089      2.879     .003    61.419
    7  3'HG          22    .043  12.160     612     1.188      26    .051    727       .283      7.397     .014   205.759
    8 16'HG          31    .020   9.840     567     1.467      45    .029    832       .089      4.048     .003    74.034
    9 C.T.          312    .066   6.070     110     2.252     702    .149    248       .021     14.752     .003     5.201
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     44.097     .038   604.310
CYCLE 4
    1 IDLE           28    .020  11.800     183     1.225      34    .024    224       .036      1.234     .001     8.068
    2 16'HG          22    .020  10.110     498     1.429      31    .029    712       .089      2.799     .003    63.356
    3 10'HG          24    .021  11.180     458     1.293      31    .027    592       .257      7.974     .007   152.164
    4 16'HG          21    .020   9.970     527     1.450      30    .029    764       .089      2.709     .003    67.991
    5 14'HG          20    .020   8.830     251     1.636      33    .033    411       .047      1.538     .002    19.303
    6 16'HG          22    .020  10.050     570     1.438      32    .029    820       .089      2.816     .003    72.947
    7  3'HG          20    .103  12.400     674     1.163      23    .120    784       .283      6.580     .034   221.738
    8 16'HG          18    .020   9.930     597     1.456      26    .029    869       .089      2.332     .003    77.357
    9 C.T.          377    .070   6.330     157     2.141     807    .150    336       .021     16.951     .003     7.059
    SUM-----------(CYCLE COMPOSITE)-----------------------------------------------------     44.933     .057   689.984

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------     59.070     .057   591.762

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------     44.515     .047   647.147

    FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(   59.070) + 0.65*(   44.515) =     49.609  PPM
                                                CO    0.35*(     .057) + 0.65*(     .047) =       .051  PERCENT
                                                NO    0.35*(  591.762) + 0.65*(  647.147) =    627.762  PPM
                                                                           CORRECTED NO =    471.781  PPM

    DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
   9-1-72     1-3               RUN 1                              K = 1.03     HUM =  86  GR/LB
   ---------------------------------------------------------------------------------------------------------------
   MASS        CONCENTRATION AS MEASURED      TOTAL    FUEL       ADJUSTED (MASS)       WT.        WEIGHTED (MASS)
   MODE        HC     CO     CO2      NO     CARBON    CONS.      HC      CO    NO2    FACT.      HC     CO  NO2(K)  HP
   ---------------------------------------------------------------------------------------------------------------

CYCLE 1
   1 IDLE      46   .045  11.75      77    11.845     1816        8      14      4    .232      1.8      3     .9    0
   2 16 HG    340   .052   9.64      90    10.059     8490      310      89     25    .077     23.9      7    1.9   18
   3 10 HG     37   .054  11.79     628    11.884    12167       41     112    213    .147      6.0     16   31.4   38
   4 16 HG     30   .029  10.19     438    10.251     8490       27      49    120    .077      2.1      4    9.3   18
   5 19 HG     31   .025   8.98     152     9.038     5902       22      33     33    .057      1.2      2    1.9    3
   6 16 HG     32   .030  10.35     493    10.415     8490       28      49    133    .077      2.2      4   10.3   18
   7  3 HG     29   .069  12.83     597    12.930    18705       45     202    287    .113      5.1     23   32.4   57
   8 16 HG     29   .032  10.51     582    10.573     8490       25      52    155    .077      1.9      4   11.9   18
   9 C.T.     427   .094   6.44      91     6.995     1907      126      52      8    .143     18.0      7    1.2    0
   SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------      3.5      4    5.7

CYCLE 2
   1 IDLE      46   .045  11.75      77    11.845     1816        8      14      4    .232      1.8      3     .9    0
   2 16 HG     35   .023  10.29     400    10.351     8490       31      38    109    .077      2.4      3    8.4   18
   3 10 HG     39   .034  11.76     567    11.836    12167       43      71    194    .147      6.4     10   28.4   38
   4 16 HG     34   .021  10.51     478    10.568     8490       30      34    127    .077      2.3      3    9.8   18
   5 19 HG     45   .022   9.03     169     9.101     5902       32      29     36    .057      1.8      2    2.1    3
   6 16 HG     35   .025  10.67     512    10.733     8490       30      40    134    .077      2.3      3   10.4   18
   7  3 HG     31   .051  12.28     700    12.364    18705       51     156    352    .113      5.7     18   39.7   57
   8 16 HG     31   .023  10.29     562    10.346     8490       27      38    153    .077      2.1      3   11.8   18
   9 C.T.     384   .082   6.26      89     6.757     1907      117      47      8    .143     16.7      7    1.2    0
   SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------      2.3      3    6.4

CYCLE 3
   1 IDLE      41   .020  11.53     211    11.594     1816        7       6     11    .232      1.6      1    2.5    0
   2 16 HG     34   .022  10.18     515    10.239     8490       30      37    142    .077      2.3      3   10.9   18
   3 10 HG     27   .031  11.35     472    11.410    12167       31      67    167    .147      4.6     10   24.6   38
   4 16 HG     27   .020   9.98     547    10.029     8490       25      34    154    .077      1.9      3   11.8   18
   5 19 HG     28   .020   8.84     183     8.890     5902       20      27     40    .057      1.1      2    2.3    3
   6 16 HG     29   .020  10.28     532    10.331     8490       26      33    145    .077      2.0      3   11.2   18
   7  3 HG     28   .048  12.23     695    12.308    18705       46     147    351    .113      5.2     17   39.6   57
   8 16 HG     27   .020  10.42     582    10.469     8490       24      33    157    .077      1.8      3   12.1   18
   9 C.T.     364   .070   6.26     110     6.723     1907      112      40     10    .143     15.9      6    1.5    0
   SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------      2.1      3    6.6

CYCLE 4
   1 IDLE      41   .020  11.53     211    11.594     1816        7       6     11    .232      1.6      1    2.5    0
   2 16 HG     33   .020  10.11     552    10.166     8490       30      34    153    .077      2.3      3   11.8   18
   3 10 HG     36   .033  11.55     514    11.622    12167       41      70    179    .147      6.0     10   26.3   38
   4 16 HG     33   .020   9.97     522    10.026     8490       30      34    147    .077      2.3      3   11.3   18
   5 19 HG     54   .020   8.73     183     8.808     5902       39      27     41    .057      2.2      2    2.3    3
   6 16 HG     35   .021  10.12     552    10.179     8490       32      35    153    .077      2.4      3   11.8   18
   7  3 HG     29   .044  12.22     674    12.295    18705       48     135    340    .113      5.4     15   38.5   57
   8 16 HG     36   .020   9.77     628     9.829     8490       34      35    180    .077      2.6      3   13.9   18
   9 C.T.     332   .064   5.64     127     6.063     1907      113      41     13    .143     16.1      6    1.9    0
   SUM-----------(CYCLE COMPOSITE)--------------------------------------------------------      2.3      3    6.8

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-------------------------------------      2.9      3    6.0

   AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-------------------------------------      2.2      3    6.7

   FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     2.9) + 0.65(     2.2) =     2.442  (MASS)
                                            CO  0.35(       3) + 0.65(       3) =       2.9  (MASS)
                                            NO2 0.35(     6.0) + 0.65(     6.7) =     6.448  (MASS)
                                                                CORRECTED NO2 =     6.656  (MASS)
```

```
    4-1-72      1-3                 RUN 2                                                 K = 1.03     HUM =  86  GR/LB
    --------------------------------------------------------------------------------------------------------------------
    MASS          CONCENTRATION AS MEASURED     TOTAL     FUEL       ADJUSTED (MASS)       WT.         WEIGHTED (MASS)
    MODE          HC       CO      CO2     NO  CARBON    CONS.      HC      CO     NO2    FACT.      HC       CO   NO2(K)  HP
    --------------------------------------------------------------------------------------------------------------------
CYCLE 1
    1 IDLE        45     .053   12.09    109   12.192     1816       7      16       5    .232      1.7       4     1.3    0
    2 16 HG       30     .056   10.99    386   11.078     8490      25      87      98    .077      1.9       7     7.6   18
    3 10 HG       31     .072   12.47    628   12.575    12167      32     141     202    .147      4.8      21    29.7   38
    4 16 HG       26     .052   10.87    567   10.950     8490      22      81     146    .077      1.7       6    11.2   18
    5 19 HG       27     .052    9.72    175    9.801     5902      18      63      35    .057      1.0       4     2.0    3
    6 16 HG       31     .066   11.73    542   11.829     8490      24      96     129    .077      1.9       7     9.9   18
    7  3 HG       24     .157   13.51    666   13.733    18705      35     542     301    .113      4.0      61    34.0   57
    8 16 HC       42     .052   10.36    674   10.457     8490      37      85     182    .077      2.8       7    14.0   18
    9 C.T.       367     .100    6.20     75    6.696     1907     113      58       7    .143     16.1       8     1.0    0
    SUM-----------(CYCLE COMPOSITE)------------------------------------------------------------    2.0       7     6.2
CYCLE 2
    1 IDLE        45     .053   12.09    109   12.192     1816       7      16       5    .232      1.7       4     1.3    0
    2 16 HG       32     .049   10.72    478   10.804     8490      27      78     125    .077      2.1       6     9.6   18
    3 10 HG       12     .062   12.06    567   12.135    12167      13     126     189    .147      1.9      18    27.7   38
    4 16 HG       10     .047   10.58    552   10.638     8490       9      76     146    .077       .7       6    11.3   18
    5 19 HG       12     .041    9.30    170    9.354     5902       8      52      36    .057       .5       3     2.0    3
    6 16 HG       17     .048   11.11    503   11.176     8490      14      74     127    .077      1.1       6     9.8   18
    7  3 HG       19     .067   13.01    705   13.098    18705      29     193     334    .113      3.3      22    37.8   57
    8 16 HG       34     .045   10.11    579   10.192     8490      31      76     160    .077      2.4       6    12.3   18
    9 C.T.       318     .087    5.94     72    6.370     1907     103      53       7    .143     14.7       8     1.0    0
    SUM-----------(CYCLE COMPOSITE)------------------------------------------------------------    1.6       4     6.4
CYCLE 3
    1 IDLE        33     .044   12.02    107   12.100     1816       5      13       5    .232      1.2       3     1.2    0
    2 16 HG       23     .049   11.33    365   11.404     8490      18      74      90    .077      1.4       6     6.9   18
    3 10 HG       19     .049   10.96    493   11.030    12167      23     109     181    .147      3.3      16    26.5   38
    4 16 HG       20     .044    9.75    552    9.816     8490      19      77     159    .077      1.4       6    12.2   18
    5 19 HG       19     .041    9.47    157    9.532     5902      13      51      32    .057       .7       3     1.8    3
    6 16 HG       21     .063   11.95    559   12.036     8490      16      90     131    .077      1.2       7    10.1   18
    7  3 HG       19     .061   12.71    689   12.792    18705      30     180     334    .113      3.4      20    37.8   57
    8 16 HG       80     .044    9.35    582    9.480     8490      77      80     173    .077      6.0       6    13.3   18
    9 C.T.       303     .079    5.81     62    6.216     1907     100      49       6    .143     14.4       7      .9    0
    SUM-----------(CYCLE COMPOSITE)------------------------------------------------------------    1.9       4     6.3
CYCLE 4
    1 IDLE        33     .044   12.02    107   12.100     1816       5      13       5    .232      1.2       3     1.2    0
    2 16 HG       28     .042   10.71    498   10.782     8490      24      67     130    .077      1.8       5    10.0   18
    3 10 HG       29     .054   11.94    537   12.025    12167      32     110     180    .147      4.7      16    26.5   38
    4 16 HG       27     .044   10.47    522   10.543     8490      23      72     140    .077      1.8       6    10.7   18
    5 19 HG       38     .042    9.19    157    9.273     5902      26      54      33    .057      1.5       3     1.9    3
    6 16 HG       27     .045   10.62    569   10.694     8490      23      72     150    .077      1.8       6    11.5   18
    7  3 HG       25     .066   12.60    705   12.693    18705      40     196     345    .113      4.5      22    39.0   57
    8 16 HG       28     .049   10.40    625   10.479     8490      24      80     168    .077      1.9       6    12.9   18
    9 C.T.       322     .088    5.86     59    6.296     1907     105      54       6    .143     15.1       8      .8    0
    SUM-----------(CYCLE COMPOSITE)------------------------------------------------------------    1.9       4     6.5

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)----------------------------------------    1.8       6     6.3

    AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)----------------------------------------    1.9       4     6.4

    FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(     1.8) + 0.65(     1.9) =    1.866  (MASS)
                                             CO  0.35(       6) + 0.65(       4) =      4.7  (MASS)
                                             NO2 0.35(     6.3) + 0.65(     6.4) =    6.339  (MASS)
                                                              CORRECTED NO2 =    6.543  (MASS)
```

```
     9-5-72       1-3                  RUN I                                      K =   .76      HUM =  21   GR/LB
     --------------------------------------------------------------------------------------------------------------------------------
     MASS        CONCENTRATION AS MEASURED     TOTAL    FUEL       ADJUSTED (MASS)      WT.          WEIGHTED (MASS)
     MODE           HC      CO      CO2     NO   CARBON   CONS.      HC     CO    NO2    FACT.     HC       CO    NO2(K)   HP
     --------------------------------------------------------------------------------------------------------------------------------
CYCLE 1
     1 IDLE         38    .021   11.79     78   11.852    1816        6      6      4    .232     1.5       2       .9     0
     2 16 HG        25    .020   10.20    330   10.247    8490       22     33     91    .077     1.7       3      7.0    18
     3 10 HG        27    .030   11.37    572   11.429   12167       31     65    202    .147     4.6       9     29.7    38
     4 16 HG        21    .020    9.92    399    9.963    8490       19     34    113    .077     1.5       3      8.7    18
     5 19 HG        20    .020    8.85    130    8.892    5902       14     27     29    .057      .8       2      1.6     3
     6 16 HG        22    .020    9.92    402    9.964    8490       20     34    114    .077     1.6       3      8.8    18
     7  3 HG        23    .049   12.02    587   12.094   18705       38    153    301    .113     4.3      17     34.1    57
     8 16 HG        28    .020    9.95    459   10.000    8490       26     34    129    .077     2.0       3     10.0    18
     9 C.T.        264    .073    6.00     47    6.358    1907       86     44      5    .143    12.2       6       .7     0
     SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     1.7       3      5.7
CYCLE 2
     1 IDLE         38    .021   11.79     78   11.852    1816        6      6      4    .232     1.5       2       .9     0
     2 16 HG        13    .022   11.00    377   11.036    8490       11     34     96    .077      .8       3      7.4    18
     3 10 HG        10    .021   10.91    373   10.942   12167       12     47    138    .147     1.8       7     20.2    38
     4 16 HG         9    .020    9.18    458    9.210    8490        9     37    140    .077      .7       3     10.8    18
     5 19 HG        10    .020    9.75    156    9.781    5902        7     24     31    .057      .4       1      1.8     3
     6 16 HG        32    .047   11.25    405   11.332    8490       26     71    101    .077     2.0       5      7.8    18
     7  3 HG         9    .143   12.96    612   13.113   18705       14    412    290    .113     1.6      47     32.8    57
     8 16 HG       278    .020    7.63    527    7.950    8490      321     43    187    .077    24.7       3     14.4    18
     9 C.T.        272    .071    6.04     52    6.405    1907       87     43      5    .143    12.5       6       .7     0
     SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     2.6       4      5.5
CYCLE 3
     1 IDLE         28    .020   11.80    183   11.850    1816        5      6      9    .232     1.1       1      2.2     0
     2 16 HG        20    .021   10.01    348   10.053    8490       18     36     98    .077     1.4       3      7.5    18
     3 10 HG        21    .022   11.14    377   11.185   12167       25     48    136    .147     3.6       7     20.0    38
     4 16 HG        19    .020    9.42    478    9.461    8490       18     36    142    .077     1.4       3     11.0    18
     5 19 HG        21    .020    8.81    183    8.853    5902       15     27     41    .057      .9       2      2.3     3
     6 16 HG        24    .024   10.72    512   10.770    8490       20     38    134    .077     1.6       3     10.3    18
     7  3 HG        22    .043   12.16    612   12.227   18705       36    133    311    .113     4.1      15     35.1    57
     8 16 HG        31    .020    9.84    567    9.893    8490       29     35    162    .077     2.2       3     12.4    18
     9 C.T.        312    .066    6.07    110    6.473    1907       99     39     11    .143    14.2       6      1.5     0
     SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     1.7       2      5.8
CYCLE 4
     1 IDLE         28    .020   11.80    183   11.850    1816        5      6      9    .232     1.1       1      2.2     0
     2 16 HG        22    .020   10.11    498   10.154    8490       20     34    138    .077     1.5       3     10.6    18
     3 10 HG        24    .021   11.18    458   11.227   12167       28     46    165    .147     4.1       7     24.2    38
     4 16 HG        21    .020    9.97    527   10.013    8490       19     34    148    .077     1.5       3     11.4    18
     5 19 HG        20    .020    8.83    251    8.872    5902       14     27     55    .057      .8       2      3.2     3
     6 16 HG        22    .020   10.05    570   10.094    8490       20     34    159    .077     1.5       3     12.3    18
     7  3 HG        20    .103   12.40    674   12.525   18705       32    311    334    .113     3.6      35     37.8    57
     8 16 HG        18    .020    9.93    597    9.969    8490       17     34    169    .077     1.3       3     13.0    18
     9 C.T.        377    .070    6.33    157    6.807    1907      114     40     15    .143    16.3       6      2.1     0
     SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------     1.8       3      6.6

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)--------------------------------------     2.1       3      5.6

     AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)--------------------------------------     1.8       3      6.2

     FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(      2.1) + 0.65(      1.8) =     1.891  (MASS)
                                              CO  0.35(        3) + 0.65(        3) =       3.1  (MASS)
                                              NO2 0.35(      5.6) + 0.65(      6.2) =     5.970  (MASS)
                                                                    CORRECTED NO2 =     4.546  (MASS)
```

APPENDIX X

ENGINE 1-3

FINAL EMISSION TESTS IN SAME CONFIGURATION AT START OF CONTROL TECHNOLOGY STUDY

TABULAR DATA

EXPERIMENTAL 23 MODE MASS

NINE-MODE FTP CONCENTRATION

NINE-MODE CALIFORNIA ARB MASS

```
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
  9-07-72 RUN-1 ENG.1-3 72 VERSION  STD.JETS + TIMING
--------------------------------------------------------------------------------------------
               DYNA.         MAN. FUEL     A/F                 DRY CONCENTRATION
MODE SPEED     LOAD     HP   VAC. LB/HR   RATIO    ALDE.     HC       CO        CO2      NO
--------------------------------------------------------------------------------------------
   1   600      0.0      0   18.1   4.1    16.2       28    2864    2.080     11.24      46
   2  1200      5.0      1   19.9   7.5    16.3       29     730     .440     12.94      81
   3  1200     18.0      4   19.1   8.3    16.5       48    1146     .210     13.18     195
   4  1200     41.0      9   17.1  10.1    17.4       41    1443     .100     12.71     480
   5  1200     57.0     13   15.8  11.0    17.9       49    1228     .100     12.47     605
   6  1200    114.0     26   10.1  16.1    18.5       64    1289     .100     11.92    1125
   7  1200    171.0     39    2.6  23.8    17.5      129     973     .100     12.71    1450
   8  1200    187.0     43    1.7  25.1    16.9      140    1299     .210     12.71    1638
   9  1200    210.0     48    1.5  27.2    15.6      130    1920    1.050     12.94    1763
  10  1200    228.0     52     .3  33.1    13.4       79    2933    4.740     11.48     825
  11   600      0.0      0   17.9   4.0    15.1       50    3600    2.870     11.60      56
  12  1200      0.0      0   22.0   4.2    19.7       58   43313     .350      5.75       8
  13  2300    246.0    108    1.3  65.8    13.0       41    2742    5.350     11.36     780
  14  2300    226.0     99    2.1  58.4    14.0       75    1441    3.290     12.22    1288
  15  2300    202.0     88    2.3  53.9    14.9       58     619    1.940     12.71     963
  16  2300    185.0     81    2.4  51.3    15.7       37     200    1.010     12.59     845
  17  2300    123.0     54   10.4  32.1    16.6       39     800     .180     12.71    2550
  18  2300     62.0     27   14.7  23.2    17.2       34     479     .180     12.09    1063
  19  2300     44.0     19   16.1  20.8    17.6       31     317     .150     11.92     685
  20  2300     20.0      9   17.6  17.8    18.0       24     189     .130     11.72     360
  21  2300      5.0      2   18.9  17.1    18.6       34     775     .130     11.48     186
  22   600      0.0      0   18.0   4.1    16.1       31    2835    1.910     11.36      66
  23  2300      0.0      0   23.8   4.3    24.7       64   32468     .280      4.84      13
--------------------------------------------------------------------------------------------
          CALCULATED GRAM/HR          WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC       CO      NO2   FAC.      HP  ALDE.      HC        CO      NO2
--------------------------------------------------------------------------------------------
   1    .8    39.1     574      2.1   .070     0.0     R        R         R        R
   2   1.6    18.5     225      6.8   .060      .1   1.4    16.17     196.7      6.0
   3   2.9    32.0     118     18.0   .060      .2    .7     7.77      28.8      4.4
   4   3.1    51.0      71     56.4   .050      .5    .3     5.45       7.6      6.0
   5   4.1    48.3      79     79.0   .030      .4    .3     3.71       6.1      6.1
   6   8.3    77.5     121    224.5   .060     1.6    .3     2.97       4.7      8.6
   7  23.3    81.4     169    402.6  0.000     0.0    .6     2.08       4.3     10.3
   8  26.3   113.3     370    474.5   .040     1.7    .6     2.65       8.7     11.1
   9  24.3   167.0    1845    509.2  0.000     0.0    .5     3.48      38.5     10.6
  10  15.5   266.6    8706    249.0  0.000     0.0    .3     5.12     167.1      4.8
  11   1.3    44.0     709      2.3   .070     0.0     R        R         R        R
  12   2.3   791.1     129       .5   .120     0.0     R        R         R        R
  13  15.5   481.9   18991    455.1   .025     2.7    .1     4.47     176.3      4.2
  14  27.2   243.8   11246    723.6   .055     5.4    .3     2.46     113.6      7.3
  15  20.8   102.8    6512    531.3   .035     3.1    .2     1.16      73.6      6.0
  16  13.7    34.2    3486    479.3   .060     4.9    .2      .42      43.0      5.9
  17   9.4    89.8     408    950.4   .060     3.2    .2     1.67       7.6     17.6
  18   6.3    40.9     311    301.5  0.000     0.0    .2     1.51      11.4     11.1
  19   5.3    24.7     236    177.3   .065     1.3    .3     1.28      12.3      9.2
  20   3.5    12.8     179     81.3  0.000     0.0    .4     1.47      20.4      9.3
  21   4.8    51.4     174     41.0  0.000     0.0   2.2    23.49      79.6     18.7
  22    .9    38.9     529      3.0   .080     0.0     R        R         R        R
  23   3.2   756.9     132      1.0   .060     0.0     R        R         R        R

CYCLE COMPOSITE    HC      8.136    GRAM/BHP HR
                   CO     70.910    GRAM/BHP HR
                   NO2     8.267    GRAM/BHP HR
                   ALDE     .285    GRAM/BHP HR
                   BSFC     .740      LB/BHP HR
                 PROJECT 11-2877-01  CONTROL TECHNOLOGY
   9-07-72 RUN-2 ENG.1-3 72 VERSION  STD.JETS + TIMING
---------------------------------------------------------------------------------------
            DYNA.        MAN. FUEL     A/F            DRY CONCENTRATION
MODE SPEED  LOAD    HP   VAC. LB/HR   RATIO   ALDE.    HC      CO       CO2      NO
---------------------------------------------------------------------------------------
  1   600     0.0    0   17.9   4.0   16.2      32   2787   1.550    12.09      54
  2  1200     5.0    1   19.9   7.4   16.6      31    900    .310    13.18      81
  3  1200    18.0    4   19.1   8.2   16.7      56   1282    .180    13.33     210
  4  1200    41.0    9   17.2   9.8   17.4      47   1141    .130    12.71     470
  5  1200    57.0   13   15.9  10.8   17.6      62   1341    .100    12.59     520
  6  1200   114.0   26   10.1  16.0   18.1      68   1591    .100    12.09    1150
  7  1200   171.0   39    2.6  23.6   17.4      96   1186    .150    12.71    1425
  8  1200   187.0   43    1.7  25.4   16.3     122   1553    .490    13.06    1825
  9  1200   210.0   48    1.5  27.3   15.3     108   2044   1.300    13.33    1762
 10  1200   228.0   52     .3  32.9   13.3      91   3278   4.740    11.48     830
 11   600     0.0    0   18.0   4.0   15.4      54   3115   2.140    12.22      63
 12  1200     0.0    0   22.0   4.2   20.3      62  46768    .350     5.16       8
 13  2300   246.0  108    1.3  66.0   12.8      46   2881   5.240    11.24     690
 14  2300   226.0   99    2.2  58.3   13.9      78   1683   3.190    12.47    1225
 15  2300   206.0   90    2.3  54.1   15.1      58    674   1.770    12.59     950
 16  2300   185.0   81    2.4  50.9   16.2      33     20     770    12.59     925
 17  2300   123.0   54   10.4  32.3   16.9      36    830      80    12.22    2500
 18  2300    62.0   27   14.8  23.0   17.6      30    478 [illegible] 11.84    1075
 19  2300    44.0   19   16.2  20.8   18.1      28    335    .150    11.60     660
 20  2300    20.0    9   17.7  17.6   18.7      20    211    .150    11.60     325
 21  2300     5.0    2   19.0  15.1   19.1      30   1281    .130    11.13     175
 22   600     0.0    0   18.0   4.1   16.0      26   3423   2.440    10.78      54
 23  2300     0.0    0   23.9   4.3   24.2      70  38087    .250     4.45       6
---------------------------------------------------------------------------------------
         CALCULATED GRAM/HR             WT.     WT.   BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.    HC       CO     NO2      FAC.     HP   ALDE.     HC       CO     NO2
---------------------------------------------------------------------------------------
  1     .9   36.3     408      2.3    .070     0.0      R        R        R       R
  2    1.6   22.2     155      6.6    .060      .1    1.4    19.47    135.5     5.8
  3    3.3   35.0      99     19.0    .060      .2     .8     8.50     24.1     4.6
  4    3.5   39.2      90     53.5    .050      .5     .4     4.18      9.6     5.7
  5    5.1   51.2      77     65.9    .030      .4     .4     3.93      5.9     5.1
  6    8.6   93.5     119    224.4    .060     1.6     .3     3.59      4.6     8.6
  7   17.1   97.8     250    390.2   0.000     0.0     .4     2.50      6.4    10.0
  8   22.2  130.6     832    509.4    .040     1.7     .5     3.06     19.5    11.9
  9   19.5  170.6    2192    488.3   0.000     0.0     .4     3.56     45.7    10.2
 10   17.7  295.6    8635    248.5   0.000     0.0     .3     5.67    165.8     4.8
 11    1.4   38.5     535      2.6    .070     0.0      R        R        R       R
 12    2.5  874.6     132       .5    .120     0.0      R        R        R       R
 13   17.6  514.4   18898    409.0    .025     2.7     .2     4.77    175.4     3.8
 14   28.2  281.2   10766    679.5    .055     5.4     .3     2.84    108.8     6.9
 15   21.2  107.9    6083    536.6    .035     3.2     .2     1.20     67.4     5.9
 16   12.4   35.9    2684    529.9    .060     4.9     .2      .44     33.1     6.5
 17    9.1   97.5     427    974.2    .060     3.2     .2     1.81      7.9    18.1
 18    5.6   41.4     263    309.3   0.000     0.0     .2     1.52      9.7    11.4
 19    4.9   26.9     243    175.4    .065     1.3     .3     1.39     12.6     9.1
 20    2.9   14.3     206     73.2   0.000     0.0     .3     1.63     23.5     8.4
 21    3.9   77.0     158     34.9   0.000     0.0    1.8    35.18     72.1    16.0
 22     .8   46.9     676      2.5    .080     0.0      R        R        R       R
 23    3.5  873.1     116       .5    .060     0.0      R        R        R       R

CYCLE COMPOSITE    HC       9.007     GRAM/BHP HR
                   CO      67.178     GRAM/BHP HR
                   NO2      8.319     GRAM/BHP HR
                   ALDE      .283     GRAM/BHP HR
                   BSFC      .736       LB/BHP HR
```

```
                PROJECT 11-2877-01  CONTROL TECHNOLOGY
 9-08-72 RUN-3 ENG.1-3 72 VERSION  STD.JETS + TIMING
--------------------------------------------------------------------------------
               DYNA.        MAN. FUEL    A/F              DRY CONCENTRATION
MODE SPEED     LOAD    HP  VAC. LB/HR  RATIO   ALDE.    HC       CO      CO2      NO
--------------------------------------------------------------------------------
  1   600       0.0     0  17.9   4.0   16.0      33   3851   2.110    12.22      49
  2  1200       5.0     1  19.9   7.6   16.3      30   1389    .520    13.48      93
  3  1200      18.0     4  19.1   8.5   16.2      46   1467    .280    13.63     195
  4  1200      41.0     9  17.1  10.0   16.9      43   1685    .150    13.18     470
  5  1200      57.0    13  16.0  11.0   17.3      61   1659    .130    12.94     570
  6  1200     114.0    26  10.1  16.1   18.2      72   1615    .100    12.22    1050
  7  1200     171.0    39   2.7  23.7   17.4     135   1099    .150    12.94    1375
  8  1200     187.0    43   1.7  25.3   16.6     121   1496    .350    13.18    1675
  9  1200     210.0    48   1.5  27.5   15.4     120   2108   1.230    13.18    1675
 10  1200     228.0    52    .3  33.2   13.3      83   3458   5.030    11.48     750
 11   600       0.0     0  18.0   4.1   14.6      47   4028   3.330    11.24      56
 12  1200       0.0     0  22.1   4.2   19.1      53  45114    .440     6.21       6
 13  2300     246.0   108   1.3  66.1   13.1      39   3065   5.350    11.60     675
 14  2300     226.0    99   2.1  58.2   14.5      69   1187   2.520    12.71    1287
 15  2300     202.0    88   2.3  53.7   15.6      51    300   1.200    12.94     913
 16  2300     185.0    81   2.4  51.2   16.2      35    149    .640    12.71     975
 17  2300     123.0    54  10.5  31.9   16.8      35    849    .130    12.47    2600
 18  2300      62.0    27  14.8  23.1   17.4      27    484    .180    12.09    1150
 19  2300      44.0    19  16.3  20.5   17.8      24    339    .150    11.84     720
 20  2300      20.0     9  17.8  17.7   18.1      22    219    .130    11.72     370
 21  2300       5.0     2  19.0  15.0   18.6      34    553    .130    11.24     210
 22   600       0.0     0  17.9   4.0   15.9      24   2775   1.870    11.24      62
 23  2300       0.0     0  23.9   4.3   23.9      60  37515    .280     4.27      10
--------------------------------------------------------------------------------
          CALCULATED GRAM/HR            WT.      WT.  BRAKE SPECIFIC GRAM/BHP-HR
MODE ALDE.     HC      CO      NO2   FAC.       HP  ALDE.     HC       CO     NO2
--------------------------------------------------------------------------------
  1     .9    47.5     526     2.0   .070      0.0     R         R        R       R
  2    1.6    33.9     256     7.5   .060       .1    1.4    29.65    224.2     6.6
  3    2.8    40.2     155    17.8   .060       .2     .7     9.79     37.7     4.3
  4    3.2    56.6     102    52.4   .050       .5     .3     6.04     10.9     5.6
  5    5.0    62.5      99    71.3   .030       .4     .4     4.80      7.6     5.5
  6    9.2    94.5     118   204.0   .060      1.6     .4     3.63      4.5     7.8
  7   23.7    89.5     247   371.8  0.000      0.0     .6     2.29      6.3     9.5
  8   22.0   125.5     593   466.5   .040      1.7     .5     2.94     13.9    10.9
  9   22.2   179.8    2120   474.4  0.000      0.0     .5     3.75     44.2     9.9
 10   15.9   309.0    9078   222.5  0.000      0.0     .3     5.93    174.3     4.3
 11    1.3    50.0     836     2.3   .070      0.0     R         R        R       R
 12    2.0   770.0     152      .4   .120      0.0     R         R        R       R
 13   14.6   532.6   18777   389.4   .025      2.7     .1     4.94    174.3     3.6
 14   25.8   204.1    8755   734.9   .055      5.4     .3     2.06     88.5     7.4
 15   19.0    51.5    4167   520.8   .035      3.1     .2      .58     47.1     5.9
 16   13.2    25.9    2247   562.5   .060      4.9     .2      .32     27.7     6.9
 17    8.6    96.8     300   984.7   .060      3.2     .2     1.80      5.6    18.3
 18    4.9    41.2     309   324.8  0.000      0.0     .2     1.52     11.4    12.0
 19    4.0    26.2     234   184.9   .065      1.3     .2     1.36     12.2     9.6
 20    3.2    14.8     178    83.1  0.000      0.0     .4     1.69     20.3     9.5
 21    4.3    32.9     156    41.5  0.000      0.0    2.0    15.03     71.4    19.0
 22     .7    37.6     512     2.8   .080      0.0     R         R        R       R
 23    3.0   881.4     133      .8   .060      0.0     R         R        R       R

 CYCLE COMPOSITE     HC       8.407    GRAM/BHP HR
                     CO      59.572    GRAM/BHP HR
                     NO2      8.433    GRAM/BHP HR
                     ALDE      .265    GRAM/BHP HR
                     BSFC      .738      LB/BHP HR
  4-8-72     1-3                RUN-2                                    K =1.060     HUM =  93  GR/LB
---------------------------------------------------------------------------------------------------------------
FEDERAL       CONCENTRATION  AS  MEASURED  DILUTION     A D J U S T E D    WEIGHTING       W E I G H T E D
MODE           HC     CO     CO2     NO      FACTOR     HC     CO    NO      FACTOR         HC       CO       NO
---------------------------------------------------------------------------------------------------------------
CYCLE 1
1 IDLE          193  1.610  12.820   117     1.048      202  1.688   123      .036        7.283    .061     4.415
2 16'HG          89   .180  12.950   628     1.104       98   .199   693      .089        8.743    .018    61.695
3 10'HG          98   .180  13.770  2451     1.038      102   .187  2545      .257       26.149    .048   653.999
4 16'HG          66   .190  13.180   726     1.086       72   .206   789      .089        6.382    .018    70.200
5 19'HG          62   .150  12.920   212     1.110       69   .167   235      .047        3.235    .008    11.061
6 16'HG          61   .210  14.060   768     1.096       67   .230   842      .089        5.950    .020    74.908
7  3'HG          61   .770  13.160  1170     1.065       65   .820  1246      .283       18.391    .232   352.739
8 16'HG          48   .180  13.180   800     1.088       52   .196   871      .089        4.650    .017    77.497
9 C.T.         1723   .420   8.050   107     1.433     2469   .602   153      .021       51.839    .013     3.219
SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  132.621    .435  1309.734
CYCLE 2
1 IDLE          193  1.610  12.820   117     1.048      202  1.688   123      .036        7.283    .061     4.415
2 16'HG          66   .180  12.940   737     1.107       73   .199   816      .089        6.501    .018    72.596
3 10'HG          60   .180  13.330  2672     1.074       86   .193  2869      .257       22.072    .050   737.221
4 16'HG          49   .180  13.060   763     1.098       54   .198   838      .089        4.785    .018    74.578
5 19'HG          55   .150  12.750   237     1.125       62   .169   267      .047        2.909    .008    12.536
6 16'HG          32   .190  12.960   820     1.108       35   .210   908      .089        3.155    .019    80.844
7  3'HG          26   .700  13.180  1265     1.069       28   .749  1353      .283        7.869    .212   382.866
8 16'HG          26   .210  13.180   980     1.089       28   .229  1067      .089        2.520    .020    94.996
9 C.T.         1670   .440   8.250   125     1.411     2357   .621   176      .021       49.497    .013     3.705
SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  106.597    .418  1463.757
CYCLE 3
1 IDLE          152  1.700  12.820   170     1.048      159  1.782   178      .036        5.735    .064     6.415
2 16'HG          53   .210  12.940   779     1.107       59   .232   862      .089        5.220    .021    76.727
3 10'HG          71   .180  13.330  2622     1.074       76   .193  2817      .257       19.603    .050   723.947
4 16'HG          40   .190  12.940   848     1.109       44   .211   940      .089        3.947    .019    83.677
5 19'HG          34   .150  12.590   265     1.142       39   .171   303      .047        1.824    .008    14.218
6 16'HG          35   .210  12.820   795     1.119       39   .235   889      .089        3.484    .021    79.146
7  3'HG          43   .700  12.940  1223     1.087       47   .761  1330      .283       13.231    .215   376.306
8 16'HG          31   .210  12.940   870     1.109       34   .233   965      .089        3.059    .021    85.846
9 C.T.         1650   .340   7.820   133     1.484     2448   .505   197      .021       51.415    .011     4.144
SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  107.519    .429  1450.426
CYCLE 4
1 IDLE          152  1.700  12.820   170     1.048      159  1.782   178      .036        5.735    .064     6.415
2 16'HG          61   .210  12.940   844     1.106       67   .232   933      .089        6.004    .021    83.075
3 10'HG          71   .150  13.180  2774     1.088       77   .163  3017      .257       19.846    .042   775.394
4 16'HG          40   .180  12.900   876     1.113       45   .200   975      .089        3.961    .018    86.738
5 19'HG          52   .150  12.470   269     1.151       60   .173   310      .047        2.812    .008    14.548
6 16'HG          40   .200  12.710   913     1.128       45   .226  1030      .089        4.016    .020    91.668
7  3'HG          40   .670  12.820  1381     1.099       44   .736  1517      .283       12.437    .208   429.372
8 16'HG          40   .180  12.700   886     1.130       45   .203  1001      .089        4.022    .018    89.096
9 C.T.         1600   .410   7.810   134     1.488     2381   .610   199      .021       50.005    .013     4.188
SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------  108.839    .412  1580.493

AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------  119.609    .427  1386.745

AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------  108.179    .420  1515.460

FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  119.609) + 0.65*(  108.179) =    112.179  PPM
                                            CO    0.35*(     .427) + 0.65*(     .420) =       .423  PERCENT
                                            NO    0.35*( 1386.745) + 0.65*( 1515.460) =   1470.410  PPM
                                                                       CORRECTED NO =   1558.557  PPM

DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
  4-8-72     1-3              WLL-2                               K = 1.15     HUM =  94  GR/LB
  ------------------------------------------------------------------------------------------------------------------
  MASS          CONCENTRATION AS MEASURED     TOTAL    FUEL     ADJUSTED (MASS)       WT.      WEIGHTED (MASS)
  MODE            HC      CO     CO2    NO   CARBON   CONS.     HC      CO    NO2   FACT.     HC      CO   NO2(A)  HP
  ------------------------------------------------------------------------------------------------------------------

CYCLE 1
  1 IDLE         193   1.610   12.82   117   14.638    1861     26     413     5    .232      6.1     96     1.1    0
  2 16 HG         89    .180   12.96   628   13.226    8354     61     230   132    .077      4.7     18    10.1   19
  3 10 HG         98    .180   13.77  2451   14.056   13438    101     346   778    .147     14.9     51   114.4   51
  4 16 HG         66    .190   13.18   726   13.441    8354     44     239   150    .077      3.4     18    11.5   19
  5 19 HG         62    .150   12.92   212   13.137    5993     31     138    32    .057      1.7      8     1.8    3
  6 16 HG         61    .210   13.06   768   13.336    8354     41     266   160    .077      3.2     20    12.4   19
  7  3 HG         61    .770   13.16  1170   13.946   19522     62    2170   542    .113     10.4    245    61.2   68
  8 16 HG         48    .180   13.18   800   13.412    8354     36     226   165    .077      2.5     17    12.7   19
  9 C.T.        1723    .420    8.05   107   10.331    1998    360     164     7    .143     51.5     23     1.0    0
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------      4.6     24    10.2

CYCLE 2
  1 IDLE         193   1.610   12.82   117   14.638    1861     26     413     5    .232      6.1     96     1.1    0
  2 16 HG         66    .180   12.94   737   13.191    8354     45     230   155    .077      3.5     18    11.9   19
  3 10 HG         80    .180   13.33  2672   13.596   13438     55     359   877    .147     12.6     53   128.9   51
  4 16 HG         49    .180   13.06   763   13.293    8354     33     229   159    .077      2.6     18    12.3   19
  5 19 HG         55    .150   12.75   237   12.959    5993     27     140    36    .057      1.6      8     2.1    3
  6 16 HG         32    .190   12.96   820   13.185    8354     22     243   172    .077      1.7     19    13.3   19
  7  3 HG         26    .700   13.16  1265   13.908   19522     36    1465   590    .113      4.5    224    66.6   68
  8 16 HG         26    .210   13.18   980   13.418    8354     17     264   203    .077      1.3     20    15.6   19
  9 C.T.        1670    .440    8.25   125   10.494    1998    343     169     8    .143     49.1     24     1.1    0
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------      3.9     23    12.0

CYCLE 3
  1 IDLE         152   1.700   12.82   170   14.684    1861     21     435     7    .232      4.8    101     1.7    0
  2 16 HG         53    .210   12.94   779   13.207    8354     36     268   164    .077      2.8     21    12.6   19
  3 10 HG         71    .180   13.33  2622   13.587   13438     76     360   861    .147     11.1     53   126.5   51
  4 16 HG         40    .190   12.94   848   13.173    8354     27     243   179    .077      2.1     19    13.7   19
  5 19 HG         34    .150   12.59   265   12.777    5993     17     142    41    .057      1.0      8     2.4    3
  6 16 HG         35    .210   12.82   795   13.068    8354     24     271   169    .077      1.9     21    13.0   19
  7  3 HG         43    .760   12.94  1223   13.686   19522     66    2017   579    .113      7.5    228    65.4   68
  8 16 HG         31    .210   12.94   870   13.183    8354     21     269   183    .077      1.6     21    14.1   19
  9 C.T.        1650    .340    7.82   133    9.942    1998    356     138     9    .143     51.2     20     1.3    0
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------      4.0     23    11.9

CYCLE 4
  1 IDLE         152   1.700   12.82   170   14.684    1861     21     435     7    .232      4.8    101     1.7    0
  2 16 HG         61    .210   12.94   844   13.216    8354     42     268   177    .077      3.2     21    13.6   19
  3 10 HG         71    .150   13.18  2774   13.407   13438     77     304   923    .147     11.3     45   135.7   51
  4 16 HG         40    .180   12.90   676   13.123    8354     26     231   185    .077      2.1     16    14.3   19
  5 19 HG         52    .150   12.47   269   12.676    5993     27     143    42    .057      1.5      8     2.4    3
  6 16 HG         40    .200   12.71   913   12.953    8354     28     261   195    .077      2.1     20    15.1   19
  7  3 HG         40    .670   12.82  1381   13.533   19522     62    1952   661    .113      7.0    221    74.7   68
  8 16 HG         40    .180   12.70   886   12.923    8354     26     235   190    .077      2.2     16    14.6   19
  9 C.T.        1600    .410    7.81   134    9.948    1998    343     166     9    .143     49.5     24     1.3    0
  SUM-----------(CYCLE COMPOSITE)-------------------------------------------------------      4.0     22    12.3

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------------      4.3     23    11.3

  AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------------      4.0     23    12.4

  FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(    4.3) + 0.65(    4.0) =    4.088  (MASS)
                                           CO  0.35(    23) + 0.65(     23) =    22.9   (MASS)
                                           NO2 0.35(   11.3) + 0.65(   12.4) =   12.015  (MASS)
                                                           CORRECTED NO2 =   12.612  (MASS)
```

```
           9-8-72      1-3                  RUN-3                                      K =1.060     HUM =  93  GR/LB
          ------------------------------------------------------------------------------------------------------------
          FEDERAL        CONCENTRATION  AS  MEASURED  DILUTION        A D J U S T E D   WEIGHTING        W E I G H T E D
          MODE            HC     CO     CO2     NO     FACTOR       HC     CO    NO      FACTOR         HC     CO       NO
          ------------------------------------------------------------------------------------------------------------
CYCLE 1
          1 IDLE         189  1.820  12.940    131     1.032       195  1.878   135      .036          7.020  .068     4.866
          2 16'HG         88   .210  12.940    784     1.103        97   .232   865      .089          8.643  .021    76.998
          3 10'HG         88   .190  13.200   2573     1.083        95   .206  2786      .257         24.491  .053   716.076
          4 16'HG         61   .210  12.940    843     1.106        67   .232   932      .089          6.004  .021    82.976
          5 19'HG         58   .150  12.820    237     1.119        65   .168   265      .047          3.050  .008    12.465
          6 16'HG         48   .210  12.790    778     1.120        54   .235   871      .089          4.784  .021    77.549
          7  3'HG         48   .770  12.940   1211     1.084        52   .835  1313      .283         14.725  .236   371.488
          8 16'HG         30   .210  12.940    878     1.109        33   .233   974      .089          2.960  .021    86.643
          9 C.T.        1714   .460   7.910    100     1.451      2488   .668   145      .021         52.238  .014     3.048
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------  123.915  .462  1432.107
CYCLE 2
          1 IDLE         189  1.820  12.940    131     1.032       195  1.878   135      .036          7.020  .068     4.866
          2 16'HG         57   .210  12.660    721     1.130        64   .237   815      .089          5.735  .021    72.541
          3 10'HG         66   .200  12.940   2731     1.106        73   .221  3020      .257         18.759  .057   776.207
          4 16'HG         39   .210  12.710    864     1.128        44   .237   974      .089          3.915  .021    86.722
          5 19'HG         51   .150  12.680    237     1.132        58   .170   268      .047          2.713  .008    12.608
          6 16'HG         35   .210  12.940    869     1.108        39   .233   963      .089          3.452  .021    85.719
          7  3'HG         35   .770  12.940   1241     1.085        38   .836  1347      .283         10.748  .236   381.091
          8 16'HG         26   .220  12.940    875     1.109        29   .244   970      .089          2.566  .022    86.342
          9 C.T.        1719   .410   8.520    111     1.370      2356   .562   152      .021         49.467  .012     3.194
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------  104.374  .465  1509.290
CYCLE 3
          1 IDLE         147  2.110  12.160    164     1.084       159  2.288   178      .036          5.738  .082     6.401
          2 16'HG         44   .210  12.340    747     1.161        51   .244   867      .089          4.545  .022    77.166
          3 10'HG         62   .150  12.750   2731     1.125        70   .169  3072      .257         17.921  .043   789.412
          4 16'HG         30   .200  12.820    805     1.119        34   .224   901      .089          2.989  .020    80.205
          5 19'HG         39   .150  12.710    251     1.130        44   .170   284      .047          2.072  .008    13.336
          6 16'HG         30   .210  12.710    854     1.129        34   .237   964      .089          3.013  .021    85.783
          7  3'HG         40   .740  12.750   1313     1.102        44   .815  1446      .283         12.470  .231   409.315
          8 16'HG         35   .210  12.820    963     1.119        39   .235  1077      .089          3.484  .021    95.871
          9 C.T.        1694   .430   8.690    133     1.351      2288   .581   180      .021         48.053  .012     3.773
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------  100.286  .460  1561.262
CYCLE 4
          1 IDLE         147  2.110  12.160    164     1.084       159  2.288   178      .036          5.738  .082     6.401
          2 16'HG         60   .210  12.470    830     1.147        69   .241   952      .089          6.126  .021    84.741
          3 10'HG         70   .180  12.710   2739     1.126        79   .203  3085      .257         20.260  .052   792.731
          4 16'HG         44   .180  12.710    875     1.129        50   .203   988      .089          4.420  .018    87.891
          5 19'HG         42   .150  12.710    278     1.130        47   .170   314      .047          2.231  .008    14.766
          6 16'HG         35   .210  12.710    864     1.128        39   .237   975      .089          3.514  .021    86.751
          7  3'HG         47   .750  12.710   1350     1.104        52   .828  1490      .283         14.682  .234   421.729
          8 16'HG         31   .210  12.710   1014     1.129        35   .237  1144      .089          3.114  .021   101.846
          9 C.T.        1620   .440   8.690    148     1.360      2204   .599   201      .021         46.277  .013     4.228
          SUM-----------(CYCLE COMPOSITE)----------------------------------------------------------  106.361  .471  1601.084

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)--------------------------------------  114.145  .463  1470.699

          AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)--------------------------------------  103.323  .466  1581.173

          FOUR CYCLE COMPOSITE - REPORTED VALUES -    HC    0.35*(  114.145) + 0.65*(  103.323) =   107.111  PPM
                                                      CO    0.35*(     .463) + 0.65*(     .466) =      .465  PERCENT
                                                      NO    0.35*( 1470.699) + 0.65*( 1581.173) =  1542.507  PPM
                                                                                 CORRECTED NO =  1634.977  PPM

          DILUTION FACTOR = 14.5/(CO2+0.5*CO+10.8*HC)
```

```
9-8-72     1-3                RUN-3                                   K = 1.05     HUM =  93  GR/LB
-----------------------------------------------------------------------------------------------------------------
MASS            CONCENTRATION AS MEASURED    TOTAL    FUEL     ADJUSTED (MASS)      WT.         WEIGHTED (MASS)
MODE             HC     CO     CO2     NO    CARBON   CONS.     HC     CO    NO2   FACT.      HC      CO   NO2(K)  HP
-----------------------------------------------------------------------------------------------------------------

CYCLE 1
         1 IDLE    189  1.820  12.94    131  14.964    1861     25    457      5   .232      5.9    106     1.3    0
         2 16 HG    88   .210  12.94    784  13.245    8354     60    268    164   .077      4.6     21    12.6   19
         3 10 HG    88   .190  13.20   2573  13.485   13438     95    382    851   .147     13.9     56   125.1   51
         4 16 HG    61   .210  12.94    843  13.216    8354     42    268    177   .077      3.2     21    13.6   19
         5 19 HG    58   .150  12.82    237  13.033    5993     29    139     36   .057      1.6      8     2.1    3
         6 16 HG    48   .210  12.79    778  13.052    8354     33    272    165   .077      2.6     21    12.7   19
         7  3 HG    48   .770  12.94   1211  13.762   19522     74   2206    570   .113      8.3    249    64.4   68
         8 16 HG    30   .210  12.94    878  13.182    8354     21    269    185   .077      1.6     21    14.2   19
         9 C.T.   1714   .460   7.91    100  10.221    1998    362    182      6   .143     51.7     26      .9    0
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      4.4     25    11.7

CYCLE 2
         1 IDLE    189  1.820  12.94    131  14.964    1861     25    457      5   .232      5.9    106     1.3    0
         2 16 HG    57   .210  12.66    721  12.932    8354     40    274    155   .077      3.1     21    11.9   19
         3 10 HG    66   .200  12.94   2731  13.211   13438     73    411    922   .147     10.7     60   135.5   51
         4 16 HG    39   .210  12.71    864  12.962    8354     27    273    185   .077      2.1     21    14.2   19
         5 19 HG    51   .150  12.68    237  12.885    5993     26    141     37   .057      1.5      8     2.1    3
         6 16 HG    35   .210  12.94    869  13.188    8354     24    269    183   .077      1.8     21    14.1   19
         7  3 HG    35   .770  12.94   1241  13.748   19522     54   2209    585   .113      6.1    250    66.1   68
         8 16 HG    26   .220  12.94    875  13.188    8354     18    282    184   .077      1.4     22    14.2   19
         9 C.T.   1719   .410   8.52    111  10.787    1998    344    153      7   .143     49.2     22     1.0    0
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      3.9     25    12.3

CYCLE 3
         1 IDLE    147  2.110  12.16    164  14.429    1861     20    550      7   .232      4.9    128     1.6    0
         2 16 HG    44   .210  12.34    747  12.598    8354     32    281    164   .077      2.4     22    12.7   19
         3 10 HG    62   .150  12.75   2731  12.967   13438     69    314    940   .147     10.2     46   138.1   51
         4 16 HG    30   .200  12.82    805  13.052    8354     21    259    171   .077      1.6     20    13.2   19
         5 19 HG    39   .150  12.71    251  12.902    5993     20    141     39   .057      1.1      8     2.2    3
         6 16 HG    30   .210  12.71    854  12.952    8354     21    274    183   .077      1.6     21    14.1   19
         7  3 HG    40   .740  12.75   1313  13.533   19522     62   2156    629   .113      7.0    244    71.1   68
         8 16 HG    35   .210  12.82    963  13.068    8354     24    271    204   .077      1.9     21    15.7   19
         9 C.T.   1694   .430   8.69    133  10.950    1998    334    158      8   .143     47.7     23     1.2    0
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      3.7     25    12.8

CYCLE 4
         1 IDLE    147  2.110  12.16    164  14.429    1861     20    550      7   .232      4.8    128     1.6    0
         2 16 HG    60   .210  12.47    830  12.745    8354     42    278    181   .077      3.3     21    13.9   19
         3 10 HG    70   .180  12.71   2739  12.966   13438     78    377    942   .147     11.5     55   138.5   51
         4 16 HG    44   .180  12.71    875  12.938    8354     31    235    188   .077      2.4     18    14.4   19
         5 19 HG    42   .150  12.71    278  12.905    5993     21    141     43   .057      1.2      8     2.4    3
         6 16 HG    35   .210  12.71    864  12.958    8354     24    273    185   .077      1.9     21    14.2   19
         7  3 HG    47   .750  12.71   1350  13.511   19522     73   2189    648   .113      8.3    247    73.2   68
         8 16 HG    31   .210  12.71   1014  12.953    8354     22    274    217   .077      1.7     21    16.7   19
         9 C.T.   1620   .440   8.69    148  10.880    1998    321    163      9   .143     45.9     23     1.3    0
         SUM-----------(CYCLE COMPOSITE)-------------------------------------------------      3.8     26    13.1

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 1 AND 2)-----------------------------      4.1     25    12.0

         AVERAGE SUM---(COMPOSITE VALUES FOR CYCLES 3 AND 4)-----------------------------      3.8     25    12.9

         FOUR CYCLE COMPOSITE - REPORTED VALUES - HC  0.35(    4.1) + 0.65(    3.8) =    3.894  (MASS)
                                                  CO  0.35(     25) + 0.65(     25) =     25.3  (MASS)
                                                  NO2 0.35(   12.0) + 0.65(   12.9) =   12.589  (MASS)
                                                              CORRECTED NO2 =   13.221  (MASS)
```

APPENDIX Y

EXPERIMENTAL 23 MODE TEST PROCEDURE FOR ENGINES IN HEAVY DUTY MOTOR VEHICLES

TEST PROCEDURE FOR HEAVY DUTY MOTOR VEHICLE ENGINES

§ 85.100 Introduction

(a) The procedures described in this subpart will be the test program to determine the conformity of new heavy duty engines with the applicable standards set forth in this part.

(b) The test procedure begins with a warm engine and consists of a prescribed sequence of engine operating conditions on an engine dynamometer with continuous examination of the exhaust gases. The test is applicable equally to uncontrolled engines and controlled engines equipped with means for preventing, controlling, or eliminating gaseous emissions.

(c) The test is designed to determine the brake specific emissions of hydrocarbons, carbon monoxide, and oxide of nitrogen when an engine is operated through a test cycle on an engine dynamometer. The test includes, in addition to three idle modes, one closed throttle and nine power modes at each of two speeds which span the typical operating range of heavy duty engines. The procedure requires the determination of the concentration of each pollutant, the exhaust flow, and the power output during each mode. The measured values are weighted and used to calculate the grams of each pollutant emitted per brake horsepower hour.

(d) When an engine is tested for exhaust emissions or is operated for durability testing on an engine dynamometer, the complete engine shall be used with all standard accessories which might reasonably be expected to influence emissions to the atmosphere installed and functioning.

§ 85.101 Fuel Specifications

(a) For exhaust emission testing of gasoline fueled engines, fuel having specifications as shown in the table in § 85.71(a), or substantially equivalent specifications approved by the Administrator shall be used.

(b) For durability testing of gasoline fueled engines, fuel having specifications as shown in the table in § 85.71(b), or substantially equivalent specifications approved by the Administrator, shall be used. The octane rating of the fuel used shall be in the range recommended by the engine manufacturer. The specifications of the fuel to be used shall be reported in accordance with § 85.51(b)(3)

(c) For exhaust emission testing of engines which use diesel fuels, fuel having specifications as shown in the table in § 85.121(b), or substantially equivalent specifications approved by the Administrator shall be used.

(d) For durability testing of engines which use diesel fuels, fuel having specifications as shown in the table in § 85.121(c), or substantially equivalent specifications approved by the Administrator, shall be used. The octane rating of the fuel used shall be in the range recommended by the engine manufacturer. The specifications of the fuel to be used shall be reported in accordance with § 85.51(b)(3).

§ 85.102 Dynamometer Operation Cycle

(a)(1) The following twenty three mode cycle shall be used in dynamometer operation tests of heavy duty engines.

MODE NO.	ENGINE SPEED*	PERCENT LOAD	WEIGHTING FACTOR
1	Idle	0	~~6.0~~
2	Intermediate	2	6.0
3	"	8	6.0
4	"	18	5.0
5	"	25	3.0
6	"	50	6.0
7	"	75	0
8	"	82	4.0
9	"	92	0
10	"	100	0
11	Idle	0	~~6~~
12	Intermediate	C.T.	12
13	High	100	2.5
14	"	92	5.5
15	"	82	3.5
16	"	75	6.0
17	"	50	6.0
18	"	25	0
19	"	18	6.5
20	"	8	0
21	"	2	0

MODE NO.	ENGINE SPEED*	PERCENT LOAD	WEIGHTING FACTOR
22	Idle	0	~~6~~ 8
23	High	C.T.	6

---

* Engine Speed Definition:

	Engine Type	
	Spark Ignition	Compression Ignition
Intermediate	1200 rpm	Peak torque speed or 60% of rated, whichever is higher.
High	2300 rpm	Rated speed

(2) For each mode the engine dynamometer shall be operated at a constant speed within ± 50 r.p.m. of the specified speed and at the specified torque within ± 2 percent of maximum torque at that speed. For example, the torque for mode six (6) shall be between 48 and 52 percent of maximum torque measured at the intermediate test speed.

(b) The following equipment shall be used for emission testing of engines on engine dynamometers.

(1) An engine dynamometer with adequate characteristics to perform the test cycle described in § 85.102(a)

(2) An engine cooling system having sufficient capacity

to maintain the engine at normal operating temperatures during conduct of the prescribed engine tests.

(3) A chassis-type exhaust system or substantially equivalent exhaust system.

§ 85.104 Sampling and Analytical Systems for Measuring Exhaust Emissions

(a) Two separate sampling and analytical systems are used for emission testing under the regulations in this part. One system is used for the determination of hydrocarbon concentrations. The other system is used for the determination of the concentrations of nitric oxide, carbon monoxide, and carbon dioxide.

The system used for determining hydrocarbon concentrations includes a heated sampling line and a heated flame ionization detector analyzer (FID). When emission tests involve gasoline fueled engines, the sample line and analyzer are maintained at a temperature of 160°F ± 5°F to prevent the water vapor in the sample stream from condensing out and collecting in the system. When emission tests involve engines which use diesel type fuels, the temperature is maintained at 350°F ± 10°F to inhibit the accumulation of the lighter weight hydrocarbons in the system as a result of condensation and adsorption effects. Means are provided for purging the system with air when measurements are not being made.

The system used for determining the concentrations of the other pollutants includes:

(1) a water concending trap which is maintained at 36°F ± 4°F,

(2) a chemiluminescence (CL) NO analyzer,

(3) a nondispersive infrared (NDIR) CO analyzer and,

(4) a nondispersive (NDIR) CO_2 analyzer.

A converter is used upstream of the chemiluminescence analyzer to convert any NO_2 in the sample stream to NO. A bypass system is provided to permit the periodic checking of the converter efficiency. Means are provided for back flushing the cooling coil and sample line and for introducing air or NO and O_2 mixtures (for converter efficiency testing) into the analytical system.

Other types of analyzers may be used if they yield equivalent results and if they are approved by the Administrator.

(b) Schematic drawing. The following (Fig. 6) is a schematic drawing of the exhaust gas sampling and analytical system which shall be used for testing under the regulations in this subpart.

(c) Component description. The following components will be used in the exhaust gas analytical system for testing under the regulations of this part.

(1) Flowmeters (FL1, FL2, and FL3) to indicate the sample flow rate through the analyzers.

(2) Analyzers to determine hydrocarbon, carbon monoxide, carbon dioxide, and nitric oxide concentrations.

(3) A converter to convert any NO_2 present in the samples to NO before analysis.

(4) Flow control valves (N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11, N13, and N14) to regulate the gas flow rates.

(5) Recorders (R1, R2, R3, and R4) or digital printers to provide permanent records of calibration, spanning, and sample measurements. In those facilities where computerized data acquisition systems are incorporated, the computer facilities printout may be used.

(6) Manifold (M1) to collect the expelled gases from analyzers.

(7) Pump (P2) to transfer expelled gases from the collection manifold to a vent external to the test room (optional)./

(8) Selector valve (V8) to direct purge air through the HC analytical system.

(9) Selector valves (V1, V2, V5, V6) to direct samples, span gases, or zeroing gas to the analyzers.

(10) Selector valves (V3 and V4) to allow the sample, span, calibrating, or zeroing gases to bypass the converter.

(11) Pump (P1) to transfer samples from sample probe to analyzers.

(12) Filters (F1 and F2) to remove particulate matter.

(13) Selector valve (V9) to direct NO/O_2 mixtures to the converter for efficiency checks.

(14) Selector valve (V7) to backflush cooling coil with air.

(15) Cooling Coil (C1) to condense water vapor from sample.

(16) Refrigerated water bath to maintain cooling coil at 32 - 40°F.

(17) Thermometer for indicating bath temperature.

(18) Valve (N12) to drain water from cooling coil.

(19) Sample probes to extract exhaust gas sample downstream of muffler.

§ 85.105 Information

The following information shall be recorded:

- (a) General
  - (1) Test number
  - (2) Date and time of day
  - (3) Instrument operator
  - (4) Engine operator
  - (5) Engine Identification - Date of manufacture - Number of hours of operation accumulated on engine - Engine family - engine displacement - timing - maximum observed torque at specified test engine speeds - idle r.p.m.
  - (6) All pertinent instrumentation information such as model name and serial numbers.
  - (7) Recorder charts. Identify zero traces - Calibration or span traces for each test mode - Start and finish of each test.
  - (8) Ambient temperature in dynamometer testing room.
  - (9) Engine intake, air temperature, and humidity.
  - (10) Barometric pressure.
  - (11) Observed engine torque for each mode.
  - (12) Other data as required by the Administrator.
- (b) Spark ignition engines
  - (1) Number of carburetors and number of carburetor venturis or fuel injection system types.

   (2) Advertised horsepower.
   (3) Fuel consumption in gms/hr during each mode.

(c) Compression ignition engines

   (1) Advertised rated and peak torque speeds.
   (2) Exhaust pipe diameter.
   (3) Exhaust system back pressure.
   (4) Air aspiration system type.
   (5) Air inlet restriction.
   (6) Fuel injection system.
   (7) Exhaust flow in c.f.m., or intake air flow in c.f.m. and fuel consumption in pounds per hour, for each mode.

(nitrogen diluent) gases having nominal concentrations equal to 50 and 100 percent of full scale. The actual concentrations should be known to within ± 2 percent of the true values.

(5) Compare values obtained on the CO and CO_2 analyzers with previous calibration curves. Any significant change reflects some problem in the system. Locate and correct problem, and recalibrate. Use best judgment in selecting curves for data reduction.

(6) Check the NO_2 to NO converter efficiency by the following procedure:

(i) Fill a plastic bag with air (or oxygen) and NO span gas in proportions which result in a mix in the operating range of the analyzer. Provide enough oxygen for substantial conversion of NO to NO_2.

(ii) Knead bag and immediately connect the bag to the inlet at valve N13. Turn selector valve N7 as required and close valve V8. Alternately measure the NO and NO_x concentration at 1-minute intervals by alternately passing the sample through the converter and the bypass (close valves N6 and N9 to minimize pump down rate of bag). After several minutes of operation, the recording of NO and NO_x will resemble Figure 1c, Section

85.84, if the converter is efficient. Even though the amount of NO_2 increases with time, the total NO_x ($NO + NO_2$) remains constant. A decay of NO_x with time indicates the converter is not essentially 100 percent efficient and the cause should be determined before the instrument is used.

(iii) The converter efficiency should be checked at least once weekly and preferably once daily.

(b) HC, CO, CO_2, and NO_x measurements: Allow a minimum of 20 minutes warmup for the HC analyzer and 2 hours for the CO, CO_2, and NO_x analyzers. (Power is normally left on infrared and chemiluminescence analyzers; but when not in use, the chopper motors of the infrared analyzers are turned off and the phototube high voltage supply of the chemiluminescence analyzer is place in the standby position.) The following sequence of operations should be performed in conjunction with each series of measurements:

(1) Zero the analyzers. Obtain a stable zero on each amplifier meter and recorder. Recheck after tests.

(2) Introduce span gases and set the CO and CO_2 analyzer gains, the HC analyzer sample capillary flow rate, and the NO_x analyzer high voltage supply to match the calibration curves. In order to avoid corrections, span and calibrate at the same flow

rates used to analyze the test samples. Span gases should have concentrations equal to approximately 80 percent of full scale. If gain has shifted significantly on the CO or CO_2 analyzers, check tuning. If necessary, check calibration. Recheck after test. Show actual concentrations on chart.

(3) Check zeros; repeat the procedure in subparagraphs (1) and (2) of this paragraph if required.

(4) Check flow rates and pressures.

(5) Measure HC, CO, CO_2, and NO_x concentrations of samples. Care should be exercised to prevent moisture from condensing in the sample collection bag.

(6) Check zero and span points.

(c) For the purposes of this section, the term "zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

§ 85.107 Test Run

(a) The temperature of the air supplied to the engine shall be between 68°F and 86°F. The observed barometric pressure shall be between 28.5 inches and 31 inches Hq. Higher air temperature or lower barometric pressure may be used, if desired, but no allowance will be made for possible increased emissions because of such conditions.

(b) The following steps shall be taken for each test:

(1) Install instrumentation and sample probes as required.

(2) Start cooling system.

(3) Start the engine, warm it up and precondition it by running it at the lower specified test speed and maximum horsepower for 10 minutes or until all temperatures and pressures have reached equilibrium.

(4) Determine by experimentation the maximum torque at the specified test engine speeds and calculate the torque values for the specified test modes.

(5) Zero and span emission analyzers.

(6) Start the test sequence of § 85.102(a). Operate the engine for ten minutes in each mode as follows:

Minute	Mode Test Sequence
1st	Complete engine speed and load changes
2nd through 7th	Pass air through sample lines and analyzers
8th through 10th	Pass exhaust sample through the lines and analyzers and continuously record analyzer response.

(7) Read and record the data required for § 85.105 during the last five minutes of each test mode.

(8) Check and reset the zero and span settings of the emission analyzers at the end of the first CT mode (mode # 12) and at the end of the test or more often if required. If a change of over two percent of full scale response is observed, make necessary adjustments to the analyzers and repeat all test modes since the last zero and span.

(9) Backflush condensate trap and replace filters as required.

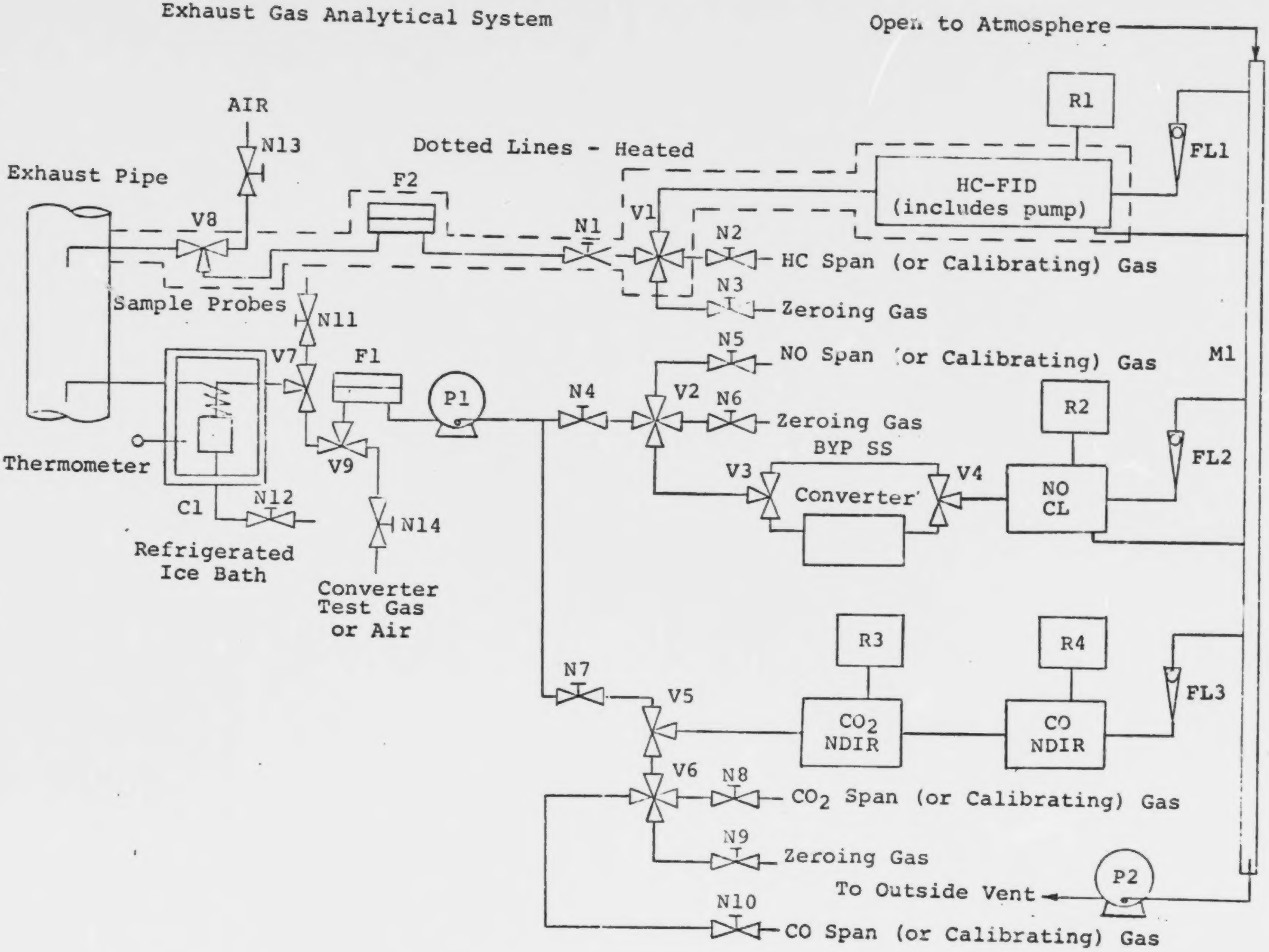
§ 85.108 Chart Reading

(a) Locate the last sixty seconds of each mode and determine the average chart reading for HC, CO, CO_2, and NO over the one minute period.

(b) Determine the concentration of HC, CO, CO_2, and NO during each mode from the average chart readings and corresponding calibration data.

Figure 6

Exhaust Gas Analytical System


Open to Atmosphere
AIR
N13
Dotted Lines - Heated
Exhaust Pipe
F2
V8
N1
V1
R1
HC-FID
(includes pump)
FL1
N2
HC Span (or Calibrating) Gas
N3
Zeroing Gas
Sample Probes
N11
V7
F1
P1
N4
V2
N5
NO Span (or Calibrating) Gas
M1
N6
Zeroing Gas
R2
FL2
BYP SS
V3
Converter
V4
NO
CL
Thermometer
V9
C1
N12
N14
Refrigerated
Ice Bath
Converter
Test Gas
or Air
N7
V5
R3
R4
FL3
CO2
NDIR
CO
NDIR
V6
N8
CO2 Span (or Calibrating) Gas
N9
Zeroing Gas
To Outside Vent
P2
N10
CO Span (or Calibrating) Gas

Office of Air Programs
Ann Arbor, Michigan 48105

AFAE

March 27, 1972

Corrections to the Experimental Heavy-Duty Test Procedure Presently Utilized at Southwest Research Institute and the Bureau of Mines

Dr. Jose L. Bascunana
Chief, Highway Vehicles Section, CCDB

In Section 85.102(a)(1) the weighting factors for mode numbers 1, 11, and 22 are revised to read as follows:

Mode No.	Engine Speed	% Load	Weighting Factors
1	Idle	0	7
11	Idle	0	7
22	Idle	0	8

In Section 85.107 paragraphs (6) and (7) are revised to read as follows:

(6) Start the test sequence of 85.102(a). Operate the engine for at least three minutes in each mode, completing the engine speed and load changes during the first minute.

(7) If additional time is required to read and record the data specified in Section 85.105, each mode may be extended to a maximum of ten minutes.

In Section 85.108 paragraph (a) is revised to read as follows:

(a) Locate the third minute of each mode and determine the average chart reading for HC, CO, CO_2 and NO over the one minute period.

John Bozek
Chief, Heavy Duty Section
Procedures Development Branch

AFAE::JJMcFadden/JBozek:lpm 209, 340, 3/27/72

FILE